

ANNUAL REPORT

OF THE

PROGRESS OF CHEMISTRY,

And the Allied Sciences,

PHYSICS, MINERALOGY, AND GEOLOGY;

Including the applications of Chemistry to Pharmacy, Medicine, Agriculture,
the Arts and Manufactures;

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PHYSICS

AND

PHYSICAL CHEMISTRY.

General Matters. Mean Value of Periodic Functions.—Napier'sky(1) has communicated a process of deducing the mean value of a periodic function from an incomplete series of observations, to which process Paucker(2) establishes a prior claim, inasmuch as he proves that he was the first to make it public(3). Paucker makes use of this opportunity to show the superiority of his method over the more indirect one of Bessel(4), according to which, to obtain the mean of the whole, the missing observations have to be calculated (by the method of least squares) from existing ones which differ equally from each other in point of time; he farther uses it to prove how much quicker the end is obtained by his process than by Plantamour's modification(5) of that of Bessel. Finally, Paucker seizes the opportunity to give a general review of his calculus of compensations, which, though already published(6), has been hitherto confined to a narrow circle of readers.

General
matters.
Mean
value of
periodic
functions.

Physical Central Observatory.—Farther intelligence regarding the Russian Central Observatory at Petersburg, mentioned in the Report of last year(7), has been given by Kupffer(8), accompanied by an interesting review of the gradual development of the simultaneous meteorological and magnetical observations over the entire earth.

Molecular Actions. Phenomena of Capillarity.—It is known that the form of the free surface assumed by very small masses of

(1) Petersb. Acad. Bull. VIII, 321; Compare also Erman (Arch. für wissensch. Kunde v. Russland, 1847, VI) and Lloyd (Annual Report f. 1849, III, 1).

(2) Petersb. Acad. Bull. IX, 113.

(3) Arbeiten d. Kurländ. Gesellsch. f. Lit. u. Kunst, No. VI, 97; IX.

(4) Schumacher's astron. Nachr. 1828, No. 136.

(5) Arch. Ph. Nat. XIV, 7.

(6) Arbeiten d. Kurländ. Gesellsch. f. Lit. u. Kunst, No. VI, VIII, IX.

(7) Annual Report for 1849, III, 2.

(8) Arch. Ph. Nat. XV, 18 from Schumacher's astron. Nachr. 1850, No. 726.

Molecu-
lar
actions.
Phenome-
na of ca-
pillary.

fluids, in consequence of the action of their molecular forces, is considerably modified, in large masses, by the weight of the latter. To neutralise the action of gravity, and at the same time to preserve the freedom of the fluid to assume any form due to other forces to which it is subjected, Plateau has applied a method peculiar to himself(1). He introduces olive oil into a mixture of water and alcohol of precisely the same density as the oil. The oil, suspended in this mixture, behaves as if it had no weight. In order to observe the figure of equilibrium formed by the oil, in its true shape, the fluid is introduced into a vessel whose opposite sides are formed of parallel plates of mirror glass, the plates being united by a metallic frame.

In this way Plateau immediately obtained a sphere of 1 decimetre diameter. The limits of the vessel alone prevented him from exceeding this magnitude.

To form a fluid cylinder, two thin discs of iron were placed parallel to each other in the mixture, like the bases of a right cylinder. Between the discs a quantity of oil was introduced sufficient to form the cylinder; its excess was carefully sucked up by means of a pipette, or else the discs were slowly removed to a greater distance from each other. The fluid assumed a complete cylindrical form, even with a diameter of 7 centimetres and a distance of 11 centimetres between the discs.

When rings of iron-wire were substituted for the discs, a cylinder was formed, the ends or bases of which were segments of spheres.

According to the general laws of capillary action, the curvature of the free surface of a fluid mass, operated on solely by its own molecular forces, must, in the case of equilibrium, satisfy the equation

$$\frac{1}{R} + \frac{1}{R'} = C,$$

where R and R' denote the greatest and the least radii of curvature, and C is a constant. Now, for all points of the cylindrical surface we have R equal to the radius of the transverse section of the cylinder, and R' , as the radius of curvature of a straight line, infinite. At all points of a spherical surface we have $R = R'$. From this, it follows that the radius of the sphere, a portion of which is formed by the swelling out of the bases of the cylinder just described, must be equal to the diameter of the cylinder. The height of the spherical segment above the base of the cylinder is easily calculated from this. For a cylinder of 35^{mm}·7 radius the height ought to be 9^{mm}·56. By measurements made with a cathetometer, Plateau found in one experiment 9^{mm}·50, and in another 9^{mm}·61. Hence,

(1) Pogg. Ann. LXXXII, 387; Ann. Ch. Phys. [3] XXX, 203; Ann. Ch. Pharm. LXXVIII, 157; extract from the Mémoires de l'Académie de Bruxelles, XVI u. XXIII.

these results show, on a large scale, a coincidence of theory and experiment, which has hitherto been observed in the case of so-called capillary effects alone.

Molecular
actions.
Phenomena of
capillarity.

In the manner before described, Plateau has obtained bodies of different shapes enclosed by plane surfaces. To form any required figure, it is only necessary to construct its edges with iron-wire. In this way, for example, he obtains a fluid cube of 7 centimetres the side. If the point of a pipette be sunk through any of the plane surfaces of a fluid polyhedron, and the fluid be sucked up, all the sides of the body sink in simultaneously, while the fluid remains attached to its wire scaffolding; we finally obtain a number of fluid leaves united together, symmetrically arranged, and each of which proceeds from one of the wires.

The fluid cylinder retains its form probably in all cases where the ratio of the length of the cylinder to its diameter does not exceed a certain quantity which lies between 3 and 3.6. When, however, this ratio is exceeded, the cylindrical surface is drawn together in one place and swells out at another; and this change, having once commenced, proceeds at an accelerated rate, so that the mass is speedily divided into two distinct portions. It was impossible to obtain fluid cylinders of greater length in the manner above indicated. Now as the cylinder, whatever be its length, is, according to the laws of capillarity, a figure of equilibrium, it must be concluded that this equilibrium beyond the ratio 1 : 3, or at most 1 : 3.6, of diameter to length, is not permanent.

By the application of particular means, Plateau has succeeded in obtaining cylinders whose length has a much greater ratio to the diameter than the above. When left tranquilly to themselves, however, they soon fall into a series of drops. Thus an iron-wire melted by the electric current, possesses no permanence of form, but divides itself into a series of little spheres.

With reference to Plateau's experimental inquiries Hagen has attempted to determine by calculation the ratio of the diameter of a stable cylinder to its length; and has found it to be that of 1 : 2.83, a result which diverges from that of Plateau(1). The latter has, however, shown that the assumption on which this calculation is based is not quite correct, and gives for the true value of the limit of stability the expression 1 : 3.14. (2).

Resolution of a Fluid Vein into Drops.—Plateau has applied his experiments on the limit of stability of a fluid cylinder to explain the phenomena exhibited by a cylindrical jet of water, and draws the inference that the latter, during its motion, must exhibit a series of

(1) Berl. Acad. Ber. November, 1849; Pogg. Ann. LXXX, 595.

(2) Pogg. Ann. LXXX, 566.

Resolution
of a fluid
vein into
drops.

contractions and protuberances at distances proportional to the thickness of the jet, and hence that we must finally arrive at a point where the jet is resolved into a series of isolated spheres(1). Plateau, it will be seen, assumes that the modification of the shape of the cylinder commences in the immediate vicinity of the orifice, although it is at first scarcely perceptible. In the discussion of the subject, however, he makes no attempt to assign a cause to which the disturbance of the equilibrium of the cylinder so soon after its formation can be referred. For although it is proved by his beautiful experiments that a fluid cylinder possesses stability only within narrow limits, it does not therefore follow, that the equilibrium of a long cylinder must cease of itself, because it is not permanent, but simply that it is liable to be destroyed by the slightest exterior influence. An external cause is necessary, the action of which, as shown by the peculiar deportment of the jet, must be very regularly periodic.

A fluid vein passing downward from a circular orifice in the bottom of a thin vessel consists, as is known, of two portions of very different characters. That nearest the orifice is clear, transparent, apparently tranquil, exhibiting in fact the appearance of a glass rod of gradually decreasing thickness; the other portion appears turbid, restless, and exhibits protuberances of varying form and position. Similar protuberances are observed at the lower end of the clear portion of the vein, and they sometimes appear farther up, even in the vicinity of the orifice.

When the superior portion of the vein is suffered to strike against a thin disc, or against the bottom of a thin vessel which is held in the hand, the sensation experienced is, with rare interruptions, that of a steady continuous pressure. The magnitude of the pressure is so constant that it can be determined by a balance. If, however, the metallic disc be held in the turbid portion of the vein, a series of shocks is experienced, the succession of which is so speedy and regular as to generate a distinct tone.

Savart(2), as is known, was the first to prove (in 1833) that the limpid portion only of the vein is continuous, while the turbid portion is made up of a series of drops, the apparent continuity being due to the fact that the drops succeed each other in intervals of time which are shorter than the duration of their impression upon the retina. By means of an ingenious apparatus, he succeeded in neutralising this apparent permanence of impression, demonstrating at the same time the continuity of the upper portion of the vein, and its resolution into drops at the point of transition to the under portion.

(1) Loc. cit. at page 2 (Pogg. Ann. LXXXII, 398; Ann. Ch. Phys. [3] XXX, 214).

(2) An. Ch. Phys. [2] LIII, 337; Pogg. Ann. XXXIII, 451.

Last year an apparatus was described by Hagen(1), which he applied to the counting of the drops and the determination of their size and distance. The apparatus consists of a pasteboard drum covered with paper, and set in uniform rotatory motion by means of a fly-wheel. When the required velocity of rotation is attained, the jet, which has been previously conducted by a groove, is permitted to fall upon the drum for a moment. If the limpid portion of the vein strike the drum, the fluid always distributes itself as a very fine stripe, quite uniformly and without protuberances. When, however, the turbid portion is thus received, a series of drops are formed which Hagen assures us are quite sharply defined and can be examined with the greatest precision and convenience. The drops follow each other with great swiftness. With a charge 9 lines in height, 80 drops might be counted in a second. It would have been interesting to compare the size of the drops with the height of the tone generated by the descending jet. Savart is known to have found that when the charge remains constant the number of vibrations excited by the shocks of the turbid vein is inversely proportional to the diameter of the orifice; and when the diameter remains constant, the number of vibrations is proportional to the square root of the charge.

Resolution
of a fluid
vein into
drops.

The length of the continuous portion of the vein was considered by Savart to be proportional to the square root of the charge, and to the width of the orifice. This law is not corroborated by the observations of Hagen. As regards the proportion where the width of the orifice is changed, the divergence from Savart is indeed trifling. When, on the contrary, the orifice is unchanged, Hagen finds that the length of the limpid portion increases in such a manner with the height of the charge, that a constant quantity must be always added, which expresses the length of the continuous part of the vein, and remains even when the pressure is a minimum. To find the distance from the orifice of the place where the resolution into drops commences, Hagen directs the hollow of a watch-glass against the jet. The profile of the continuous portion is then seen sharply defined and darkly coloured; where the interruption commences the outline is indistinct and the colour brighter. Hagen himself, however, states that inasmuch as the jet is liable to be modified by the slightest accidental circumstance, this, as well as every other mode of measurement, must be attended with great uncertainty.

Tyndall(2), has lately drawn attention to the fact that the resolution of the vein into drops is rendered very distinct when the descending fluid is momentarily illuminated by the electric spark. In repeating

(1) Pogg. Anh. LXXVIII, 466.

(2) Phil. Mag. [4] I, 105; Pogg. Ann. LXXXII, 302.

Resolution
of a fluid
vein into
drops.

this experiment Buff found(1) that the light of the interrupted galvanic current was peculiarly suited to the exhibition of the phenomenon. To break the current he made use of a small wheel indented at its circumference like the teeth of a saw. With the axis of the wheel one pole of the battery was connected, and against its teeth a spring pressed which was connected with the other pole, and which, when the wheel was turned, was forced to spring from tooth to tooth. In order to obtain in this way a sufficiently brilliant stream of light from a moderate number of cells, it was found necessary to introduce a coil of wire into the circuit. By the light thus obtained, the vein forms a sharply defined shadow, which, received upon a white screen, reveals at once the nature of the vein and permits us even to follow its details. Of the descending drops some appear to be almost spherical, others very much extended in length, others again flattened and broad. This corresponds perfectly with the view of Savart, according to which the apparent protuberances in the turbid portion of the vein are due to the circumstance that the drops, at the moment of their separation, contract themselves in one direction and afterwards endeavour, by their capillary action, to assume the spherical form, which, however, is not assumed until after a series of periodic contractions and expansions. As these oscillations proceed sometimes in the general direction of the mass, sometimes in the opposite direction, and always with great velocity, the consequence is the tremulous motion which, under ordinary circumstances, is observed in the under portion of the vein. At the moment when the drop detaches itself from the continuous portion, the lower end of the latter is drawn out to a thread which, in virtue of its capillary action, springs back against the thicker liquid stem, thus causing a wave-like protuberance at the end of the limpid portion which is distinctly visible by momentary illumination, and which contributes to the formation and separation of the drop. These protuberances, which occur before the jet is broken, show themselves only at the lower end of the continuous vein where the outflow is uniform. Whenever they make their appearance near the orifice, which indeed is frequently the case, though a regular succession is not observed, it is a certain sign that a rupture of the vein has occurred at the place in question, in consequence of accidental causes.

Formation of Bubbles in Water.—On the occasion of an inquiry into the motion of fluids, Magnus has endeavoured to explain the formation of the air-bubbles which are exhibited when one mass of water is poured into another(2). The phenomenon appears to him to be due to the formation of a cavity at the place where the descending water meets the surface of the tranquil fluid. This cavity is covered up, and air enclosed when the slightest motion is imparted to the

(1) Ann. Ch. Pharm LXXVIII, 162.

(2) Pogg Ann. LXXX, 12.

surface, the air being carried down through the liquid by the descending water.

Formation
of bubbles
in water

In a later and more extended investigation by Tyndall(1), this explanation has been rendered more complete. It is here proved that for the regular and permanent formation of the bubbles it is necessary that the uncontinuous portion of the vein shall be intersected by the surface of the water into which it falls. When a vessel filled with water is so placed that the surface of the fluid cuts the continuous portion of the descending vein, if the latter flow tranquilly, not only are there no bubbles formed, but the water rises at the bottom of the fluid column, as it would do in the case of a glass rod. It is, however, only necessary to pass the blade of a knife through the vein to cause the generation of bubbles. The same result follows whenever the vein is ruptured by shaking or any other cause.

Every heavy body, a grain of shot for example, thrown into water draws an air-bubble after it, evidently because the air enters the space opened by the passage of the shot more quickly than the water, until finally the space is enclosed by the return of the fluid above. The same conditions exist in the disconnected portion of the vein; the drops, although separated from each other by sensible intervals, follow in such quick succession that the water at the place of incidence is regularly driven downwards, thus causing an ascending motion of the liquid around.

Single drops, or those which follow each other so slowly that they cannot prevent the oscillation of the surface at the place of incidence, sink slowly and to no great depth into the water, forming no bubbles.

Experiment of Leidenfrost. (Spheroidal state). The property of many fluids to assume the form of drops upon red-hot surfaces has been the subject of several investigations during the past year. Boutigny(2), whose peculiar manner of explaining the experiment of Leidenfrost has been already reported(3), arrived at the conclusion that fluids in the spheroidal condition are repelled to a certain distance from the heated surface underneath. As an additional proof of the existence of this enigmatical repulsive force, he now adduces the fact that when placed upon a sieve of red-hot platinum-wire, water, alcohol, ether and iodine, assume the spheroidal form, and do not pass through the wire meshes(4), while the vapours of these fluids pass through readily.

(1) Phil Mag [4] I, 105; Pogg. Ann LXXXII, 294.

(2) Compt Rend. XXXI, 279; Inst. 1850, 274; Babinet's Report in Compt. Rend. XXXI, 509.

(3) Compare Annual Report for 1847 and 1848, I, 69; for 1849, III, 26.

(4) The priority of observation is claimed by Zantedeschi in Compt. Rend. XXXI, 683; Boutigny's Reply in Compt. Rend. XXXI, 750; Compare Müncke in Pogg. Ann. XIII, 248.

Experi-
ment of
Leiden-
frost.
(Sphero-
idal state).

This in itself truly interesting experiment, possesses, however, no validity in the sense in which Boutigny applies it. With equal right might it be asserted that mercury is repelled by silk, because it does not pass through the gauze meshes of the latter.

Person(1), although agreeing with Boutigny as to the existence of an interval between the drop and the heated surface, contends against the existence of a force of repulsion. He had already(2) given utterance to the opinion that the drop was borne by a layer of vapour, and he does not regard this opinion as refuted by the foregoing experiment. He endeavours on the contrary to prove, by direct determinations of the pressure exerted by the vapour beneath the drop, that its tension, even between the meshes of the red-hot sieve, is sufficiently great to support the fluid.

The experiment of Poggenpuff(3), which shows that the electric current does not pass from the drop to the heated surface, speaks also in favour of the existence of an interval. Buff(4) has, however, shown that this experiment is not universally correct. In the case of large drops formed from good conducting fluids in particular, the electric current, though certainly diminished, is not interrupted. Other important grounds, however, can be adduced against the notion that the insulation of the drop is the necessary cause of the phenomenon. Ether, as first observed by Légal(5), assumes on the surface of heated water or oil the same spheroidal shape as on a red-hot plate. It is here observed that the fluid on which the ether rests, bends all round the spheroid, and that the latter, like every other body which swims on the fluid but is not wet by it, is repelled with violence from the wet walls of the vessel.

If a tolerably large drop be formed in a red-hot silver basin, and a thick copper-wire be passed through the drop until it meets the bottom, by regulating the fire, the fluid round the wet surface of the copper may be caused to boil, while the surface of the basin remains unmoistened as before.

Schnauss(6) and, before him, Böttger(7), have described a very characteristic star-like form, which drops of considerable volume generally assume in large, flat, metallic basins heated to redness. The former, who observed the fact most accurately, finds that the star always consists of an even number of rounded protuberances, and that the entire phenomenon is due to the formation of stationary undulations. This formation of undulations presents a difficulty, if we do

(1) *Compt. Rend.* XXXI, 899.

(2) *Compt. Rend.* XV, 492; *Pogg. Ann.* LVII, 292.

(3) *Pogg. Ann.* LII, 539.

(4) *Ann Ch. Pharm.* LXXVII, 1.

(5) *Compt. Rend.* XXX, 182.

(6) *Pogg. Ann.* LXXIX, 432.

(7) *J. Pr. Chem.* X, 108; *Comp. Pogg. Ann.* LXXXI, 320.

not suppose the drop to rest upon the bottom of the vessel, so that the vapour generated at its under surface cannot freely escape, but must, as it were, force a way for itself, in doing which it must move the fluid before it in the same direction, and thus compel the drop to bend at other places.

Experiment of
Leiden-
frost.
(Spheroidal state).

Buff(1) finds the origin of the spheroidal state, on hot surfaces, in an alteration of the ratio of the attraction exerted by the surface upon the fluid particles to the attraction of the latter for each other.

The adhesion between the walls of a vessel and the fluid within it is diminished when the temperature is increased, as also the cohesion of the fluid. That water wets the surface of a vessel is known to be due to the fact that the attraction between the vessel and the fluid particles is greater than the attraction of the latter for each other. This excess generally continues to exist when the fluid and the vessel are uniformly heated. The interior surface of an evaporating basin possesses a temperature only a little exceeding that of the boiling fluid which wets it. If, however, this interior surface can be heated considerably higher than the fluid, the force of adhesion must diminish more quickly than the cohesion of the fluid. Sooner or later, therefore, a temperature will be attained at which the cohesion surpasses the adhesion, and consequently, according to the known laws of capillarity, the spheroidal shape will be assumed, and the wetting of the surface cease.

From this point of view we are able to understand why it is that the experiment of Leidenfrost, though succeeding with various kinds of fluids, is capable of being made only with such as form vapours, and which therefore cannot in open vessels be heated beyond a certain temperature; why it is that the experiment does not succeed with the fatty oils; why it is that the temperature of the plate with different fluids, which are to assume the spheroidal shape, need not be the same, but is so related to the boiling points of the fluids that it must always be greater than the latter.

A fluid in the spheroidal state, though resting upon the surface beneath it, is not however in intimate contact with the surface. The transmission of heat is thus rendered more difficult, similar to the passage of electricity under the same circumstances. It is not, however, the less true that the evaporating drop abstracts a considerable quantity of heat from the surface underneath, and hence it is that vessels of good conducting metal are best suited for the experiment of Leidenfrost.

Fiery Ordeal.—Boutigny, as before mentioned(2), has introduced anew into the domain of physics the remarkable fact that naked portions of the human body may be brought for a moment into contact with intensely heated metals (the fiery ordeal of the ancients) without

(1) Loc. cit. p. 8.

(2) Annual Report for 1849, III, 26.

Fiery ordeal.

suffering injury; he explains the fact by showing that the moisture of the hand does not wet a glowing metallic surface. His experiments have been since repeated and corroborated in various places.

To execute the experiment without danger, Come(1) recommends the precaution of removing the layer of oxide which might readily attach itself to the skin. When, previous to immersion, he moistened his hand with fluid sulphurous acid, he experienced in melted lead, and even in fused iron, the sensation of cold. A similar result was obtained by Légal(2), when, before introducing his hand into the lead-bath, he had moistened it with ether. A modification of the experiment, described by Légal(3), consists in the immersion of the hand moistened by ether in boiling water.

Diffusion of Liquids.—By the *diffusion of liquids*, Graham denotes the passage of a substance out of a fluid in which it is held in solution into a farther quantity of the same fluid, or the voluntary distribution of a soluble substance in the dissolving medium. In connection with this subject, Graham has recently published some extensive researches(4), the principal results of which we will here endeavour to describe.

Graham in the first place directs attention to the fact, that not only the quantity of the dissolved substance, but also the force with which the medium holds the body in solution, must be taken into account. The latter force may be different in solutions which contain equal quantities of solid substance; thus, for example, salts of equal solubility are removed by charcoal in different proportions from aqueous solutions.

The diffusion of carbonic acid in water proceeds but slowly. Of two bottles whose mouths were ground down so as exactly to fit each other, the under one was filled with water containing carbonic acid, the upper one with distilled water. Even after several days the water underneath was still much richer in acid than that above. From aqueous solutions carbonic acid diffused during a certain time into pure water in the same proportion as into water which contained absorbed nitrous oxide.

Mechanical mixing must of course be distinguished from the pure action of diffusion; the mechanical mixture of a solution with a fluid placed above it by change of temperature, trifling shocks, &c., is not

(1) Compt. Rend. XXX, 298.

(2) Compt. Rend. XXX, 451.

(3) Compt. Rend. XXX, 182.

(4) Philos. Transactions for 1850, I, 1; Phil. Mag. [3] XXXVII 181, 254, 341; Chem. Soc. Qu. J. III, 257; Ann. Ch. Pharm. LXXVII, 56, 129; Ann. Ch. Phys. [3] XXIX, 197; a short abstract in Phil. Mag. [3] XXXVI, 139; Arch. Ph. Nat. XIII, 217.

to be dreaded if the sp. gr. of the solution is only $\frac{1}{1000}$ greater than that of the fluid placed above it. (Graham executed all his experiments at the most equable temperatures possible.)

Diffusion
of liquids.

Different salts in solutions of equal sp. gr. diffuse differently through water in the same time. Glasses of the most similar shapes possible, capable of containing 6 ounces of water, were filled to the neck with solutions of different salts, the sp. gr. of the solutions (with the exception of that of chloride of potassium which was 1.178), being 1.200, and rendered completely full by the careful addition of distilled water; they were then placed in a larger vessel into which a quantity of water, about 5 times the volume of the solution, was poured, so that the water stood about an inch above every glass. The diffusion proceeded during twenty-seven days from the solution in the glasses into the surrounding water, the temperature being 19° ; the glasses were then covered with plates of glass, removed from the vessel, and the quantity of the substance diffused in the latter determined. In the following table, A denotes the quantity of the substance contained in 100 parts of water in the original solution; B the quantity of substance (in grains) which, at the conclusion of the experiment, was found in the surrounding water (the salts made use of were free from water.)

	A	B		A	B
Chloride of sodium . .	34.2	269.8	Acid sulph. of potassa . .	31.9	319.0
Hydrated nitric acid . .	37.9	581.2	Nitrate of soda . . .	32.4	260.2
Hydrated sulph. acid . .	29.0	455.2	Sulph. of magnesia . . .	22.4	95.9
Chlor. of potassium . .	34.9	320.3	Sulph. of copper . . .	21.6	77.5

All experiments on the diffusion of salts and other substances were carried out in a manner substantially the same as that just described.

Solutions of chloride of sodium which contained to 100 parts of water, 4, 3, 2 and 1 of salt respectively, yielded in the same time (eight days), and under the same circumstances, quantities of salt which were very nearly proportional to the numbers 4:3:2:1. At higher temperatures more chloride of sodium was diffused than when the temperature was low, and the increase seemed to be proportional to the increase of temperature. From a solution containing A chloride of sodium to 100 parts of water, at the given temperatures, the following quantities of chloride of sodium (in grains) diffused in eight days:

A.	at $4^{\circ}2$.	at $11^{\circ}4$.	at $19^{\circ}4$
1	2.63	2.78	3.50
2	5.27	5.54	6.89
3	7.69	8.37	9.90
4	10.00	11.11	13.60

In a series of experiments in which chloride of sodium diffused in water, the vessels made use of being as much alike as possible, it was

Diffusion
of liquids.

found that during eight days' action, the quantity diffused each day was nearly constant. Of 108 grs. of the salt contained in the primitive solution 13.1 grs. passed over into the water during the period of time above-mentioned.

Farther experiments had reference to the unequal diffusion from solutions which contained equal quantities of different substances. From solutions, examined as above, containing for every 100 grs. of water 20 grs. of the following substances, and possessing (at $15^{\circ}6$) the sp. grs. attached, the following quantities of substance passed over into the water in eight days, at a temperature of $15^{\circ}8$. The quantities (as will always be the case in the following tables) are expressed in grains :

	Sp. gr.	Diffused.		Sp. gr.	Diffused.
Chloride of sodium	1.126	58.5	Crystallised cane-sugar	1.070	26.74
Sulph. of magnesia	1.185	27.4	Fused cane-sugar	1.066	26.21
Nitrate of soda	1.120	51.6	Starch-sugar	1.061	26.94
Hydrated sulph. ac.	1.108	69.3	Molasses of cane-sugar	1.069	32.55
			Gum arabic	1.060	13.24
			Albumen	1.053	3.08

From a solution containing albumen the same quantity of another substance was diffused as from a solution in pure water under the same circumstances.

In the same manner it was determined how much substance from solutions (of the given sp. gr.) diffused in eight days, where the proportion by weight was 10 parts of the substance to 100 of water :

	Sp. gr. at $15^{\circ}6$.	Diffused	
		at $3^{\circ}0$	at $15^{\circ}3$.
Chloride of sodium	1.0668	22.5	32.2
Nitrate of soda	1.0622	22.8	30.7
Chloride of potassium	1.0596	—	40.2
Chloride of ammonium	1.0280	31.1	40.2
Nitrate of potassa	1.0589	28.8	35.5
Nitrate of ammonia	1.0382	29.2	35.3
Iodide of potassium	1.0673	28.1	37.0
Chloride of barium	1.0858	21.4	27.0
Hydrated sulphuric acid	1.0576	29.9	36.9
Sulphate of magnesia	1.0965	13.1	15.5
Sulphate of zinc	1.0984	12.6	15.8

Graham directs attention to the fact that of some isomorphous substances (chloride of potassium, chloride of ammonium, nitrates of potassa and ammonia(1), sulphate of magnesia and zinc) equal quantities diffused.

From solutions composed of 100 parts of water to 4 of anhydrous acid, and possessing at $15^{\circ}6$ the sp. gr. given below, the following quantities were diffused in eight days at a temperature of $15^{\circ}2$:

(1) From solutions of 1 of salt to 5 of water unequal quantities of nitrate of potassa and nitrate of ammonia diffused ; at $11^{\circ}4$ of the former 57.9 and of the latter 82.1.

	Sp. gr.	Diffused.		Sp. gr.	Diffused.
Nitric acid	1.024	28.7	Oxalic acid	1.024	12.4
Hydrochloric acid . .	1.023	34.1	Arsenic acid	1.032	12.2
Sulphuric acid . . .	1.032	18.5	Tartaric acid	1.019	9.8
Acetic acid	1.009	18.2	Phosphoric acid* . .	1.028	9.1

* Tribasic.

Graham farther investigated the diffusion of solutions of copper, which to 100 parts of water contained 4 of the salt, compared with solutions having the precipitated oxide re-dissolved by an excess of ammonia. The results of an eight days' experiment were as follows :

	Sp. gr. at 18°3.	Diffused		Sp. gr. at 18°3.	Diffused
Sulphate of ammonia .	1.024	12.0	Nitrate of ammonia .	1.014	15.8
Sulphate of copper . .	1.037	6.3	Nitrate of copper . .	1.032	9.8
Ammoniacal „ . . .	1.031	1.4	Ammoniacal „ . . .	1.023	1.5

	Sp. gr. at 19°8.	Diffused
Chloride of ammonium	1.014	16.6
Chloride of copper	1.033	10.6
Ammoniacal chloride of copper	1.021	4.2

It hence appears, that from the ammoniacal solutions less salts of copper diffused than from the purely aqueous ones.

If the solution contain a mixture of salts which do not enter into chemical union, they neither diffuse in equal quantities, nor in the same ratio, as they would singly when dissolved in the same quantity of water. From a solution of 1 anhydrous sulphate of magnesia, and 1 hydrate of sulphuric acid to 10 of water, during four days, at 16°4, 5.6 sulphate of magnesia, and 21.9 of hydrate of sulphuric acid diffused, during eight days, 9.5 sulphate of magnesia, and 29.3 hydrate of sulphuric acid. From a solution of 1 sulphate of soda and 1 chloride of sodium to 10 of water, there diffused, in four days, at 16°4, 9.5 of the former and 17.8 of the latter salt. From a solution of 4 carbonate of soda and 4 chloride of sodium to 100 water, there diffused during seven days, at 14°4, 5.7 carbonate of soda, and 12.4 chloride of sodium; while from a solution of 4 carbonate of soda alone to 100 water, at 12°4, 7.3 carbonate of soda diffused in the same time; and from a solution of 4 chloride of sodium to 100 water, under the latter circumstances, the diffusion of the salt was 11.0. In all these cases the diffusibility of the less diffusible salt is shown to be diminished in the mixture. From solutions of 10 nitrate of potassa to 100 water, and from 10 nitrate of ammonia to 100 water, equal quantities of salt were diffused, (comp. p. 12), while from a mixed solution of 10 nitrate of potassa and 10 nitrate of ammonia to 100 water, during eight days, at 15°2, 28.4 of the former and 36.2 of the latter salt, at 11°4, 25.9 of the former and 30.4 of the latter diffused. From a solution of 1 sulphate of zinc and 1 sulphate of magnesia (both anhydrous) to 6 of water, the quantities of both salts diffused in eight days were not alike, but amounted, as mean result, to 7.9 of the former and 8.7 of the latter.

Diffusion
of liquids.

From this Graham is led to regard diffusion as a means of partially separating the constituents of saline mixtures. Thus, from a solution of 1 carbonate of potassa and 1 carbonate of soda to 10 of water, in nineteen days, and at a temperature of $15^{\circ}6$, the salts diffused in the ratio of 63.6 of the former to 36.4 of the latter; and in an experiment of twenty-five days' duration, nearly the same proportion (64.8 to 35.2) was observed.—Sea-water could be partially decomposed by diffusion, so as to render the diffused mixture comparatively poorer, and the remaining portion comparatively richer, in salts of magnesia. The variability in the composition of the water of the Dead Sea, is referred by Graham to the circumstance, that during the rainy season a layer of sweet water is formed above the salt water, and that the salts from the latter are diffused with different velocities and in different proportions through the former. Into a glass cylinder 11 inches high, and having a volume of 64 cubic inches, 8 cubic inches of a saturated solution of carbonate of lime in water containing carbonic acid were poured; the water contained besides 200 grns. of chloride of sodium in solution; the remaining space was carefully filled with water. After six months the salts were still unequally distributed in the fluid; the four quarters of the cylinder, reckoned from bottom to top, contained chloride of sodium in the proportions 24.0 : 23.6 : 23.4 : 21.9 and carbonate of lime in the proportions 0.42 : 0.38 : 0.22 : 0.10.

According to Graham, diffusion can cause chemical decomposition. From a saturated solution of bisulphate of potassa at 20° , 31.8 of bisulphate of potassa and 12.8 hydrate of sulphuric acid, diffused, in fifty days, so that here a partial decomposition of the salt must have taken place. From a solution of 4 anhydrous alum in 100 water, at a temperature of $17^{\circ}9$, 5.3 of alum and 2.2 sulphate of potassa, diffused, in eight days, the partial decomposition of the alum observed here was corroborated by several other experiments.—The ammoniacal sulphate of copper is, according to Graham, also partially decomposed, and sulphate of ammonia formed.—A solution of sulphate of potassa in lime-water, containing $\frac{1}{2}$ per cent of sulphate of potassa, was surrounded with lime-water; after seven days the latter showed an alkaline reaction perceptible after the precipitation of the lime by carbonic acid, and evaporating to dryness; the sulphate of potassa was in this case decomposed and free potassa diffused(1). Chloride of potassium and chloride of sodium did not exhibit this decomposition during their diffusion in lime-water.

With reference to the diffusion of double salts, Graham made the

(1) This decomposition of sulphate of potassa in lime-water by diffusion has been corroborated by Graham in later experiments, and the same proved true for sulphate of soda, &c. He has also shown that chloride of sodium in lime-water is decomposed by diffusion, when sulphate of lime is also present, and thus explained some of the remarkable decompositions observed by Scheele and Bertholet. (Chem. Soc. Qu. J. III, 60.)

following experiments. From a solution which contained 4 parts of anhydrous sulphate of magnesia and potassa (1·65 sulphate of magnesia and 3·35 sulphate of potassa) to 100 parts of water, in seven days at 14°·4, 7·95 of the double salt diffused. From a solution containing 1·65 sulphate of magnesia to 100 of water, 2·20 of the salt were diffused under the same circumstances; and from a solution containing 2·35 of sulphate of potassa to 100 water, 5·78 of the salt diffused. From this it appears that the diffusion of the double salt (7·95) is equal to the diffusion of the single salts contained in it ($2·20 + 5·78 = 7·98$).—Graham imagines that the constituents of a double salt may be dissolved together in water without being chemically united; a solution prepared of 1·65 sulphate of magnesia and 2·35 sulphate of potassa to 100 water yielded, by diffusion in water, only 7·30 salt to water, while under the same circumstances a solution of 4 sulphate of magnesia and potassa to 100 water yielded 7·95, a perceptibly greater quantity of salt. In like manner sulphate of copper and potassa yielded by diffusion in water 30 salt to the latter; while, under the same circumstances, an equally composed solution, in which the sulphate of copper and the sulphate of potassa were introduced singly, yielded only 25·6 of salt.

Diffusion
of liquids.

From a solution of 4 carbonate of soda to 100 water an equal quantity of salt diffused into pure water as, under the same circumstances, into salt water which contained 4 parts of chloride of sodium to every 100 of water. A slight diminution of the diffusive capacity of carbonate of soda was observed when, instead of into pure water, it was permitted to diffuse into a solution containing 4 of sulphate of soda to 100 parts of water. The diffusive capacity of nitrate of potassa (4 salt to 100 water) was the same towards pure water as towards a solution containing 4 nitrate of ammonia to 100 of water.

Graham finally found groups of salts, the members of which, at least in dilute solutions, exhibit equal diffusibility. In the numerous experiments which refer to this point, he made use of glasses which contained about 4 ounces of water, and the mouths of which were 1·2 inches in diameter; these glasses were filled with solutions which to 100 parts of water contained 2, 4, 6½ and 10 parts of salt; they were then placed in a larger vessel and surrounded by 20 ounces of water. The quantities of salt (in grains) diffused during seven days, at different temperatures, were determined. We give here the mean results only of the experiments, at mean temperatures:

		2	4	6½	10
Carbonate of potassa . . .	170·9	5·5	10·3	16·7	24·7
Sulphate of potassa . . .	"	5·5	10·6	17·2	23·6
Sulphate of ammonia . . .	"	5·6	10·5	16·8	22·2
Chromate of potassa . . .	17·8	5·8	11·2	17·6	24·8
Acetate of potassa . . .	"	5·9	10·7	16·5	24·9
Bicarbonate of potassa . . .	"	5·8	11·0	—	—
Bichromate of potassa . . .	18·1	5·7	11·5	—	—

Diffusion
of liquids.

		2	4	6½	10
Nitrate of potassa . . .	18° 8	7.5	14.0	22.4	32.5
Nitrate of ammonia . . .	"	7.7	14.5	22.7	34.2
Chloride of potassium . . .	19 0	7.7	15.3	24.9	36.9
Chloride of ammonium . . .	"	7.8	14.6	24.3	36.5
Chlorate of potassa . . .	17 8	7.2	13.3	20.8	—
Carbonate of soda . . .	17.8	4.1	7.8	12.2	16.9
Sulphate of soda . . .	"	4.3	8.2	13.5	19.1

The coincidence in the diffusion of the members of each one of these groups, was exhibited most plainly in dilute solutions, as Graham has proved by a series of experiments where the solution first applied contained to 100 of water only 1 of salt. Under these circumstances ferrocyanide and ferricyanide of potassium yielded nearly the same results as sulphate of potassa.

Nitrate of potassa and carbonate of potassa, when equally strong solutions are made use of, exhibit unequal diffusions in the same time. But Graham found, that in dilute solutions, the same quantity of nitrate of potassa diffused in 7 days as of carbonate of potassa in 9.9 days, which periods are in the ratio of $1 : \sqrt{2}$. The same was exhibited on applying a solution containing 1 per cent of nitrate of potassa and sulphate of potassa; of both salts equal quantities were diffused in 3.5 and 4.95 days; in 7 and 9.9 days, and in 10.5 and 14.85 days, times which are in the ratio of $1 : \sqrt{2}$. The periods of equal diffusion for equally strong solutions of hydrate of potassa and nitrate of potassa were also in the ratio of $1 : \sqrt{2}$, and the same was found true for nitrate of soda and carbonate of soda. For several other salts Graham also found that the squares of the times within which equal quantities of salt are diffused from equally strong solutions, stand in simple ratios to each other. Following up the analogy presented by the diffusion of gases—where the squares of the times in which equal quantities of different gases diffuse are proportional to the densities of these gases—Graham also denotes the ratio of the squares of the times in which equal quantities of dissolved salts respectively diffuse, as the ratio of the "solution densities" of these salts. He ascribes to sulphate of potassa a solution density four-fold, to nitrate of potassa two-fold that of the hydrate of potassa. These solution densities are, according to him, to be referred to a new description of molecules, different from the chemical atoms, and which in the various substances possess either the same weight, or weights which stand in simple ratios to each other.

Atomology. Crystallography.—Bravais has continued(1) his previous researches(2) in crystallography, especially with reference to

(1) Instit. 1850, 189.

(2) Annual Report for 1849, III, 8.

twin crystals; Möbius(1) has communicated researches into the law of symmetry of crystals, and the application of this law to the classification of crystals in systems. Leymerie(2) considered it necessary for the explanation of the forms of tourmalines to suppose an especial triangular system of crystals as a subdivision of the hexagonal system.

Nicklès has put forward(3) here in detail the opinion already previously expressed by him(4) that the angles of the crystalline form of a body may be considerably altered by the presence of a small amount of impurity, and even thinks that a small impurity may produce crystallization in another system, as indeed for instance the square sulphate of protoxide of nickel ($\text{NiO} \cdot \text{SO}_3 + 7\text{HO}$) contains somewhat more sulphuric acid than the rhombic.

G. Rose(5) has continued his investigations concerning the metals which crystallize in rhombohedrons(6).—In some needle-shaped crystals of *tellurium*, which were formed by the spontaneous decomposition of a solution of telluride of potassium in water, he observed the combination of an hexagonal prism with a rhombohedron, whose surfaces were placed on the edges of the prism, and met in the edges of the end at an angle only a slight degree less than $71^\circ 51'$; the end edges of this rhombohedron are consequently just as much inclined to the axis as the end edges of the six-faced point produced by the pure tellurium. Scales of tellurium which had been formed by the decomposition of telluride of ammonium, showed microscopical crystals which seemed to be very thin basic rhombohedrons.—Rose also reckons *telluride of bismuth* or the *tetradymite* among the metals which crystallize in rhombohedrons; for its rhombohedron on the end edges of which the increase to quadruple crystals takes place, Haidinger's measures give the angle of the end edges $81^\circ 2'$, and for that usually occurring the angle of the end edges $66^\circ 10'$. Rose regards the sulphur contained in the tetradymite not to be essential, but he considers it possible that the sulphur may supply the place of the tellurium.—With regard to the *zinc* in crystals, which exhibited small bevelled faces, between the faces of an hexagonal prism and the end face, Rose found the inclination of these bevelled faces to the end face from $110^\circ 31'$ to $111^\circ 50'$.

Hausmann(7) has communicated additions to metallurgic crystallography, which essentially enlarge the accounts previously given by him and others, on the subject. The crystals obtained by metallurgic

(1) Berichte der Gesellsch. d. Wissensch. zu Leipzig; math.-phys. Klasse, 1849, II, 65.

(2) Compt. Rend. XXX, 707; Inst. 1850, 178.

(3) Laur u. Gerh. C. R. 1850, 103; Compt. Rend. XXX, 350, (in abstr.)

(4) Annual Report for 1847 and 1848, I, 12.

(5) Berl. Acad. Ber. 1850, 258; J. Pr. Chem. LI, 165; Instit. 1851, 43.

(6) Annual Report for 1849, III, 19.

(7) Abhandlungen der k. Gesellsch. d. Wissensch. zu Göttingen, IV; separately published as "Beiträge zur metallurgischen Krystallkunde," Inst. 1850, 308, (in abstr.)

Atomology.
Crystallography.

operations, here described by him, belong to the following substances: *silver*, *lead*, *copper* (all three exhibited only octohedrons); *iron* (he thinks now with Karsten(1) that the crystallization of the so-called specular iron does not belong to the regular system, and that the fractures through it are not directions of cleavage, but surfaces of separation); *bismuth*; *sulphide of lead* (only in cubes with the laminated structure of the native); *sulphide of zinc* (usually compact masses of remarkable laminated structure, more porous than the native); *oxide of zinc* (he considers it now with Descloizeaux(2) as crystallizing hexagonally); *suboxide of copper* (only in cubes); *sesquioxide of iron*; *silicate of protoxide of iron* (chrysolite); *bisilicate of protoxide of iron*; *chytrophyllite* (a slag of an iron furnace of a remarkable laminated structure); *Humboldtite*; *felspar*; *sulphate of lead*; *arsenite of copper*?; *arsenate of nickel*.

Connection between Composition and Crystalline Form.—On the subject of the relations between composition and crystalline form, various researches have been published, which partly have for their especial object to consider Scheerer's theory of polymeric isomorphism, and Hermann's theory of heteromerism, partly to consider, besides the composition, the sp. gr. and to investigate the specific volume for similar crystalline forms. Scheerer, as is known, understands by polymeric isomorphism, that unequal equivalents of different bodies can replace one another in a combination without change of form, for instance MgO and $3H_2O$, $2SiO_2$ and $3Al_2O_3$; Hermann understands by heteromerism, that combinations of altogether different chemical composition possess similar crystalline forms, and may unite into a more compound body of similar crystalline form. For previous objections against both theories, see the Report for 1847 and 1848, p. 379, &c.

Kobell(3) has communicated discussions concerning isomorphism, dimorphism, polymerism and heteromerism, of which he considers the following propositions to be the results. There are mixtures (in the narrower and wider sense) which are crystallographically and stoichiometrically equivalent; to these mixtures belongs the *monomeric isomorphism*.—There are mixtures which are equivalent crystallographically, but not stoichiometrically; to these belongs the *polymeric isomorphism* (with heteromerism).—Isomorphism in general has its origin in the approximate equality of the specific volumes of the mixtures in question; if the specific volumes of two or more isomorphous mixtures calculated from their simple atomic weights are not equal, this shows that they are polymerically isomorphous, and correspond not to an equal, but to an unequal number of atoms; that number of atoms belongs then to

(1) Handb. d. Eisenhüttenkunde, 3, Ausg. I, 181.

(2) Ann. Min. [4] I, 488.

(3) Anzeigen der Münchener Academie, 1850, Nr. 61 bis 64; J. Pr. Chem. XLIX, 469.

each one, for which the specific volumes become equal.—Dimorphism, trimorphism, &c., can have their origin in many cases in this, that dimorphous crystals do not contain the same absolute number of atoms of their otherwise equivalent mixture, that therefore such a crystal of the one crystalline system of the mixture (M), may contain in a second m (M), in a third m' (M), and so on, where m , m' represent the number of constituent atoms.

Con-
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between
composi-
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crystal-
line form.

Dana(1) has considered the groups of minerals; the members of which for similar, or nearly similar crystalline form have very different chemical formulæ and specific volumes, and thinks that he has found an explanation of the agreement of the forms of such substances in the fact, that numbers nearly agreeing or bearing simple ratios to one another, result from their specific volumes, when the specific volume of each substance (as it is given by the division of the specific gravity into the atomic weight resulting from the assumed formula) is divided by the number of atoms of acid and base, or by the number of elementary atoms which is contained in the formula. In the latter way especially, according to Dana concordant results are obtained. Chrysolite, serpentine, Epsom salts (sulphate of magnesia), villarsite, and picrosmine exhibit, for instance, with great agreement in the crystallographic ratios, very different formulæ and specific volumes, but numbers, nearly agreeing, result from the division of the specific volume by the corresponding number of elementary atoms that are contained in each formula; the same is the case for quartz and chabazite, for pyroxene, borax and Glauber-salts, for the different kinds of feldspars, &c., Dana thinks, by isomorphism must be understood not only similarity of form with analogous composition, but even altogether differently composed substances may be isomorphous, and then have specific volumes, which, when they are reduced in the manner just described, are equal or in simple ratios to one another. The former kind of isomorphism he distinguishes as *isomeric*, the latter as *heteromeric* isomorphism. Dana finds Scheerer's assumption that 3 atoms of water may replace 1 atom of magnesia without change of form, not justified. He comes farther to the conclusion, that in a combination, the elementary atoms may not be immediately united to one another, but that under the mutual influence each is altered, and becomes the same product of the effective molecular forces; consequently, that all atoms contained in a compound are similar to one another.

Scheerer(2) has given a more complete collection of the facts, which he considers as proofs of polymeric isomorphism, and combats the(3) objections which Rammelsberg(4) has lately raised against this theory.

(1) Sill. Am. J. [2] IX, 220; appendix, *ibid.* IX, 407 und X, 121.

(2) Liebig's, Poggendorff's and Wöhler's Handwörterbuch der Chemie, IV, 170.

(3) J. Pr. Chem. L, 449.

(4) Rammelsberg's Handwörterb. d. Chem. Mineral., 4. Suppl.

Relation
between
composition
and
specific
gravity.

Relation between Composition and Specific Gravity. — Avogadro(1) has, in continuation of his previous investigations(2), sought to determine from the specific volumes, more accurately and numerically the place which the elements occupy in the electro-chemical series; so he is of opinion that for the elements the expression for this place (the number affinity, as he expresses it), is proportional to the cube root of the specific volume, that the affinity number of a combination depends simply on the numbers of affinity and quantities by weight of the component parts, and that the true atomic weight of a substance may differ in simple ratios from its chemical equivalent. The number of affinity for 'gold being put = 1, he finds, for instance, for oxygen 0.307, for fluorine 0.354, for chlorine 0.806, for silver 0.958, for sulphur 1.029, for mercury 1.071, for copper 1.109, for nitrogen 1.135, for tin 1.150, for zinc 1.238, for potassium 1.306, for barium 1.355, for magnesium 1.359, for sodium 1.380, for hydrogen 3.010.

Thermology. Development of Heat by Chemical Combination.—

The Report on the knowledge of the development of heat by chemical combination, presented by Andrews to the British Association, has already been mentioned in last year's Report(3). As it now lies before us in a more complete form(4) we can make several important additions, particularly later results obtained by Andrews himself.

The experiments hitherto made on the absorption of heat by the solution of salts in water afforded no accurate calculation of the thermal effects, because the specific heats of the solution of the salt which was obtained, were unknown. Andrews has determined the specific heats of some solutions of nitrate of potassa, nitrate of soda, and chloride of sodium, and obtained the following results:

Salts.	Salt to 100 parts of water.	Specific gravity	Specific heat	
			observed	calculated
Nitrate of potash, 1st solution . . .	25 290	1.1368	0.8135	0.8463
" " 2nd " . . .	12 645	1.0728	0.8915	0.9145
" " 3rd " . . .	6.322	1.0382	0.9369	0.9566
Nitrate of soda, 1st " . . .	42 490	1.2272	0.7838	0.7847
" " 2nd " . . .	21 245	1.1256	0.8585	0.8736
" " 3rd " . . .	10 622	1.0652	0.9131	0.9307
Chloride of sodium, 1st solution . .	29 215	1.1724	0.8018	0.8224
" " 2nd " . . .	14 607	1.0942	0.8671	0.9000

(1) Arch. Ph. Nat. XIII, 17, Ann. Ch. Phys. [3] XXIX, 248.

(2) Annual Report for 1849, III, 15.

(3) Annual Report for 1849, III, 19.

(4) Report of the 19. Brit. Assoc. 63; Phil. Mag. [3] XXXVI, 511; Arch. Ph. Nat. XV, 231, J. Pr. Chem. L, 469; Ann. Ch. Pharm. LXXVI, 160, (in abstr.).

The true specific heat of these solutions of salts is therefore always less than that calculated from the component parts.—By eight times successively dissolving 7·99 grms. of nitrate of potassa in 250 grms. of water, Andrews obtained the following decrements of temperature :

Thermo-
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Develop-
ment of
heat by
chemical
combina-
tion.

1. 2°·65 C.	3. 2°·34 C.	5. 2°·06 C.	7. 1°·87 C.
2. 2°·49 „	4. 2°·22 „	6. 1°·97 „	8. 1°·75 „

By eleven times successively dissolving 12·22 grms. of nitrate of soda in 250 grms. of water, the decrements of temperature were :

1. 2°·80 C.	4. 1°·89 C.	7. 1°·47 C.	10. 1°·27 C.
2. 2°·43 „	5. 1°·75 „	8. 1°·39 „	11. 1°·21 „
3. 2°·11 „	6. 1°·60 „	9. 1°·33 „	

One part of water would have been raised in temperature about 590°, 407°, and 309°, by the quantity of heat which was absorbed in experiments 1, 4, and 9, by the solution of one part of the salt. Andrews gives a summary of the quantities of heat which were developed by the mixture of sulphuric acid with successive equivalents of water, according to the experiments of Hess, Graham, Abria, and Favre and Silbermann :

	Hess.	Graham.	Abria.	Favre and Silbermann.
SO ₃ + HO	6 a	—	6·02 a	—
SO ₃ HO + HO	2 a	2 a	2·00 a	2·00 a
SO ₃ 2 HO + HO	a	0·72 a	0·95 a	0·93 a
SO ₃ 3 HO + HO	} a	1·35 a	0·57 a	0·53 a
SO ₃ 4 HO + HO			0·35 a	0·32 a
SO ₃ 5 HO + HO			0·22 a	0·26 a
SO ₃ 6 HO + x. HO	a	1·18 a	— a	—

The unit *a* is not the same with the different experimenters. With Hess, *a* was at first 38·9, afterwards he increased it to 44·26 and 46·55. Abria's unit was 39·33. That of Favre and Silbermann 32·35. Graham did not determine his unit.

On the law already cited in last year's Report, that when an acid combines with a base so as to form a neutral salt, the quantity of heat disengaged is determined by the base, that consequently the same base disengages equal quantities of heat in combining with the most different acids, Andrews makes some especial remarks. While nitric, phosphoric, arsenic, hydrochloric, hydriodic, boracic, chromic and oxalic acids by combination with potassa developed the quantity of heat 6·61, sulphuric and sulphurous acids gave 0·7, or when an excess of acid was used 0·5 more than that mean, citric, tartaric, and succinic acids 0·5 less. Andrews does not give up the above law on account of these exceptions, but ascribes the deviations to foreign disturbing influences. Moreover, he considers the law only applicable to acids, which are capable of neutralizing the alkaline reaction of the

Thermo-
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Develop-
ment of
heat by
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base, hydrocyanic, carbonic, and arsenious acids do not develop so much heat as the previous acids.

We take this opportunity of communicating some results which Andrews has obtained(1) by the displacement of one metal by another. There is developed, in units of heat

	1 grm. of the metal	1 equiv. precipitated
By replacing copper by zinc	878	3435
" " " by iron	692	2342
" " " by lead	268	1061
" " silver by zinc	426	5747
" " " by copper	161	2176
" " lead by zinc	182	2357
" " mercury by zinc	333	4166
" " platinum by zinc	899	11088

The law already previously communicated(2) that when *C* is replaced by *A*, as much heat is disengaged as when *C* is replaced by *B*, and *B* by *A*, together, is confirmed in this case.

• 1 equiv. of lead replaced by zinc gives 2357
" of copper " by lead " 1061

Therefore 1 equiv. of copper " by zinc gives 3418

The result of experiment is 3435.

1 equiv. of copper replaced by zinc gives 3435
" of silver " by copper " 2176

Therefore 1 equiv. of silver " by zinc " 5611

The result of experiment is 5747.

Farther by the displacement of 1 equiv. of mercury by zinc 731 units should be disengaged, of 1 equiv. of platinum by copper 7650, of 1 equiv. of platinum by mercury 6919 units.

When a precipitate is formed by the mixture of two neutral salt-solutions, a certain quantity of heat is always disengaged, depending on the heats of liquefaction of the elements, as well as on the specific heat of the precipitated compound. Anhydrous bodies do not develop so much heat in precipitation as salts with water of crystallization.

Andrews has determined for the salts of baryta and lead, which he precipitated by a soluble sulphate, how many degrees 1 grm. of water is heated by the precipitation of 1 grm. or 1 equiv. ($O=1$) of the precipitate.

	Heat developed for 1 grm. 1 equiv. of sulph. of baryta.			Heat developed for 1 grm. 1 equiv. of sulph. of baryta.	
Chloride of barium with			Chloride of barium with		
Sulphate of magnesia.	250.31	3690.9	Sulphate of zinc . . .	220.3	3250.1
" of soda	200.3	2940.5	Protosulphate of iron	250.6	3730.2

(1) Pogg. Ann. LXXXI, 71 aus Philos. Trans. f. 1848.

(2) Annual Report for 1847 and 1848, I, 40.

Heat developed for 1 grm. 1 equiv. of sulph. of baryta.			Heat developed for 1 grm. 1 equiv. of sulph. of baryta.		Thermo- logy. Develop- ment of heat by chemical combina- tion.
Chloride of barium with			Sulphuric acid with		
Sulphate of copper . . . 24 ⁰ .7 350 ⁰ .4			Chloride of barium . . . 44 ⁰ .9 645 ⁰ .6		
" of ammonia. 24 ⁰ .2 352 ⁰ .1			Nitrate of baryta . . . 39 ⁰ .8 580 ⁰ .2		
" of sulph. of baryta.			Acetate of baryta . . . 49 ⁰ .4 720 ⁰ .2		
Nitrate of baryta with			of oxalate of baryta.		
Sulphate of magnesia. 21 ⁰ .7 316 ⁰ .4			Oxalic acid with		
" of soda . . . 20 ⁰ .5 298 ⁰ .9			Acetate of baryta . . . 22 ⁰ .5 309 ⁰ .0		
" of zinc . . . 22 ⁰ .0 320 ⁰ .7			of sulphate of lead.		
" of copper . . . 23 ⁰ .7 346 ⁰ .2			Sulphuric acid with		
of sulphate of lead.			Acetate of lead . . . 28 ⁰ .6 542 ⁰ .0		
Acetate of lead with			Nitrate of lead . . . 16 ⁰ .4 309 ⁰ .8		
Sulphate of magnesia. 9 ⁰ .9 187 ⁰ .6			of oxalate of lead.		
" of soda . . . 8 ⁰ .4 159 ⁰ .2			Oxalic acid with		
" of zinc . . . 3 ⁰ .9 73 ⁰ .9			Acetate of lead . . . 4 ⁰ .3 79 ⁰ .3		

In his determinations of the quantities of heat developed by the solution of metals in nitric acid, Andrews found :

	1 grm.	1 equiv.
Zinc	1420 units.	5857
Copper	650	2578

Other metals, such as iron, silver, bismuth, were dissolved either not completely enough or not quickly enough to allow of accurate measurements.—In the solutions in nitric acid the greatest part of the heat developed depends on the oxidation, for the numbers obtained for 1 equiv. of the metal were, for zinc and copper for instance, nearly in the ratio of the heats of combustion of these metals in oxygen, 5366 and 2394.

Hydrogen, carbonic oxide, cyanogen, iron, tin and antimony disengage nearly the same amount of heat in combining with an equal volume of oxygen; yet this agreement ceases to exist when corrections are applied to the quantities of heat immediately measured on account of the change of physical state. Protoxide of tin is next to this group; the heat of combustion of phosphorus is but little greater.—Sulphur, copper, and suboxide of copper, disengage somewhat more than half the heat of combustion of the previous group: carbon is between the two groups. The heat of combustion of zinc, and still more of potassium, is greater than that of all the bodies already enumerated.

As regards the combustion of organic compounds, it follows from the determinations of the heats of combustion of several hydrocarbons and ethers by Favre and Silbermann that, if from each compound we subtract the oxygen in the form of water, the heat of combustion of the remaining elements is by no means the same as in the free state.

Since then, from what has preceded, hydrogen develops as much heat in combustion as iron and twice as much as copper, it

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logy.
Develop-
ment of
heat by
chemical
combina-
tion.

is at once explained why in the reduction of oxide of iron by hydrogen no perceptible evolution of heat takes place, while the reduction of oxide of copper takes place with ignition.

The combustion of carbon in protoxide of nitrogen, according to Favre and Silbermann, develops more heat than its combustion in oxygen. Hence by the decomposition of protoxide of nitrogen into its elements, heat should be set free, and this Favre and Silbermann actually state that they observed.

As regards the comparison of the heat developed by combustion in oxygen with that developed by combustion in chlorine, bromine and iodine, we must refer to the communication in last year's Report(1).

Development of Heat by the Compression of Air. — J. Garrie(2) has endeavoured to determine the heat disengaged by the compression of air by experiments on a large scale. The air was compressed by means of a condenser, and at the same time at each stroke of the piston water was injected in fine streams into the space full of air; this absorbed the greatest part of the heat developed, and then together with the air was carried over into an iron receiver of about 62 cubic feet content. Although the author has applied corrections to the results of his experiments on account of a residue of the heating of the air by compression, on account of heat lost by radiation and heat generated by friction in the apparatus, yet he does not consider them to be accurate, partly because the requisite data for an accurate determination of the corrections were wanting, and partly because he had the command of only an imperfect thermometer and no barometer at all. We do not, therefore, enter farther into the work, and content ourselves with stating here the final result, which expresses approximately the ratio of the elevations of temperature of the water injected when the condensation of the air was 2, 4, 6, 7, and 8 fold.

Amount of condensation.	Elevation of the temperature of the water.
2	5.125
4	7.333
6	8.333
7	8.500 (calculated by interpolation)
8	8.666

Mechanical Equivalent of Heat. — Joule(3) has repeated the determination of the mechanical equivalent of heat in a numerous series of experiments by the already previously applied method of the friction of a solid body against a fluid, and besides also by the friction of two

(1) Annual Report for 1849, III, 17.

(2) Sill. Am. J. [2] X, 39 and 214.

(3) Phil. Trans. 1850, Part I, 61; Chem. Soc. Qu. J. III, 310; Phil. Mag. [3] XXXV, 533; Ann. Ch. Pharm. LXXVI, 170.

discs of cast-iron fitting well upon one another, which were surrounded by mercury. In order to set aside all objections which were possible against his previous experiments, Joule has omitted no precautionary measure; and no correction, which could in any way come into consideration.—The motion of the axis was produced by a descending weight; in each experiment Joule made the weight descend twenty times, and then observed the elevation of temperature which was exhibited. The portion of the mechanical power which communicated the final velocity to the descending weight, as well as that which served to overcome the friction of the pulleys and the stiffness of the cords, was deducted. Also the correction on account of the heat given off to the surrounding space was accurately calculated by direct observations of the rate of cooling.

Mechanical equivalent of heat.

The results which Joule obtained were expressed in metregrammes for 1° C.

		Equiv. in air.	Equiv. <i>in vacuo</i> .
By the friction of water		424 42	423 90
" " mercury, 1st series		424 49	423 96
" " " 2nd "		425 88	425 36
" " cast-iron 1st "		426 26	425 73
" " " 2nd "		425 12	424 60

Joule considers the results obtained with the cast-iron discs somewhat too great, because during the experiment they sounded, and consequently a part of the mechanical power was applied to the production of sonorous vibrations. Joule believes he may assume 423.55 metregrammes as the true mechanical equivalent of heat(1).

Mechanical Theory of Heat.—The constant numbers which Joule found in different ways for the mechanical equivalent of heat, have caused that the mechanical theory of heat has been worked at anew by Clausius(2) and Rankine(3); the above-named mathematicians proceed on the hypothesis that when heat disappears to the perception or becomes latent, an equivalent value in work is always performed, which either produces internal molecular changes, or comes to light as external pressure which can be applied at pleasure. That work may conversely be transformed into heat, Joule's experiments prove, and generally also the abundant production of heat by friction.—Carnot(4) who treated the mechanical theory of heat first, and in an ingenious manner, and Clapeyron(5) who has exhibited analyti-

(1) Compare Annual Report for 1847 and 1848, I, 41, and for 1849, III, 20.

(2) Pogg. Ann. LXXIX, 368, 500; LXXXI, 168; Berl. Acad. Berl. 1850, 42, (in abstr.); Inst. 1850, 245.

(3) Edinb. Trans. XX, Part I, 147; Proceedings of the Royal Soc. of Edinb. 1850, 275, (in abstr.)

(4) Réflexions sur la Puissance Motrice du Feu, et sur les Machines propres à développer cette Puissance. Paris, 1824

(5) Pogg. Ann. LIX, 446 and 566, from Journ. de l'Ecole Polytechn. XIV, 170 (1834).

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cally Carnot's theoretical development, have not assumed the possibility of a production of heat; on the contrary, they have considered the absolute quantity of all existing heat as thoroughly invariable. They have set out from the opinion that when a mechanical effect is produced by heat, this is only occasioned by the fact that a certain quantity of heat passes from a hotter to a colder body, as for instance, in the steam-engine out of the boiler into the condenser. Since such a passage, as is known, may take place without any mechanical effect at all, they proved that the maximum effect was only produced when all the arrangements were so made that only bodies of equal temperature came in contact.—The manifold consequences which Carnot and Clapeyron deduced from their theory agreed altogether so well with the results of experiment, that the papers of Joule and Mayer were the first to draw attention to the necessity of a new foundation for the theory.

Clausius makes no assumption as to the kind of motion in the interior of bodies which may be conceived as the peculiar cause of the phenomena of heat, but only supposes generally that a motion of the particles exists, and that the heat is a measure of the *vis viva* of this motion. The principle which he places at the head runs thus: *in all cases where mechanical effect is produced by heat, a quantity of heat is used up proportional to the mechanical effect produced, and conversely the same quantity of heat can be again generated by the expenditure of just so much mechanical effect.* He remarks that, according to this, the so-called *aggregate heat* of the gases or vapours must by no means be regarded as one necessarily invariable magnitude, for the same volume and the same temperature; that, for instance, if a gas is brought from temperature t_0 and volume v_0 to temperature t and volume v , the quantity of heat requisite for this is different, according as the gas is first raised at the volume v_0 from t_0 to t , and then allowed to expand at temperature t from v_0 to v , or if the result (v, t) is produced in some other way. As the quantity of heat, so also the work done in those different cases is different.

Although the laws of Mariott and Gay-Lussac, as Regnault has shown, do not hold strictly for any gas, yet the deviations are small and diminish the farther the gas is from its point of condensation; Clausius has therefore in his researches assumed the equation $v = R(a + t)$ to hold, v representing the volume of a gas at pressure p , R a constant, t the temperature, and $\frac{1}{a}$ the coefficient of expansion, so that $a = 273$ nearly.

The fundamental equations are derived by means of the same methods which were made use of by Carnot and Clapeyron, and which consist essentially in supposing that the same quantity of gas expands by heating and diminution of pressure, and is then brought back in some other manner to its original condition, and in expressing

the mechanical effect produced by it and the quantity of heat expended. For the permanent gases Clausius finds the former $= R \frac{dv}{v} \frac{dt}{dt}$, the

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latter
$$= \left\{ \frac{d}{dt} \left(\frac{dQ}{dv} \right) - \frac{d}{dv} \left(\frac{dQ}{dt} \right) \right\} dv \cdot dt.$$

According to the new hypothesis the quotient of these magnitudes is constant $= A$ suppose,

so that
$$\frac{d}{dt} \left(\frac{dQ}{dv} \right) - \frac{d}{dv} \left(\frac{dQ}{dt} \right) = \frac{AR}{v}. \quad [2]$$

while, according to Carnot's hypothesis, the mechanical effect was to be put down as proportional to the quantity of heat carried over, in the changes of the gas described.

Clausius reduces equation [2] to the form of a total differential equation

$$dQ = dU + AR \frac{a+t}{v} dv. \quad [3]$$

where U is an arbitrary function of v and t , and comprises the members which correspond to the free heat, and the heat expended in internal work, while the last member $AR \frac{a+t}{v} dv = A \cdot p \cdot dv$ corresponds to the external work performed.

Similarly the fundamental equation for vapours at the maximum density was obtained on the assumption of the following processes. The total volume of fluid and vapour is first increased without change of temperature and pressure, by a constant source of heat, A , supplying the necessary heat: then A is removed and the space still more expanded, by which a new quantity dm of vapour is formed and the temperature sinks from t to t' : then the space is again diminished till the original total volume of fluid and vapour is again attained, and the heat developed is carried off by a body B of constant temperature t' ; finally B is removed, and the diminution of volume continued till the original temperature t is again attained, so that all the conditions are the original conditions. If σ = the volume at temperature t of the quantity dm of fluid, which became vapour during the process employed and was then condensed again, s = the volume at the same temperature t , as vapour at its maximum density, then the mechanical effect produced $= (s - \sigma) \frac{dp}{dt} dm dt$, in which the above-described changes are taken

exceedingly small. On the other hand, if r is the quantity of heat which becomes latent while the unit of weight of the fluid at temperature t , and the corresponding pressure becomes vapour, c the specific heat of the fluid, $h dt$ the quantity of heat which must be communicated to the unit of weight of the vapour that its temperature

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may be raised from t to $t + dt$ at the same time that the pressure is increased so that it is again at its maximum density, the quantity of heat employed is $\left(\frac{dr}{dt} + c - h\right) dm dt$, and by the assumed principle we have:

$$\frac{dr}{dt} + c - h = A \cdot (s - \sigma) \frac{dp}{dt} \quad [4].$$

If, instead of this principle, the quantity of heat were assumed constant, we should have $\frac{dr}{dt} + c - h = 0$; hence, according to the known law of Watt(1) that the sum of the free and latent heat is constant, we should have $\frac{dr}{dt} + c = 0$, consequently also $h = 0$, which would express that if steam at its maximum density was compressed in a vessel impervious to heat, it would remain at its maximum density. Since, however, Regnault(2) found $\frac{dr}{dt} + c = 0.305$, h also would = 0.305; nevertheless, it will appear further on that h is negative, and we must thence conclude (first consequence) that of steam at its maximum density a portion is condensed not by compression but by expansion.

In order to arrive at farther conclusions with reference to gases, Clausius adds now the very probable, subordinate hypothesis, that for these bodies the expenditure of heat for internal work is zero, so that consequently a permanent gas, if it expands at a *constant* temperature, only swallows up as much heat as is necessary for the external mechanical work done by it. Hence then, the function U in equation [3] cannot contain v but can only be dependent on t , so that we have:

$$dQ = c dt + AR \frac{a+t}{v} dv \quad [5].$$

The specific heat under a constant volume or a constant pressure is obtained from this equation by making v or p constant,

$$\frac{dQ}{dt} = c \text{ and } \frac{dQ}{dt} = c' = c + AR;$$

consequently (second consequence) for each gas the difference of the two specific heats is a constant quantity (that is, is independent of the temperature), which moreover, since $R = \frac{p_0 v_0}{a + t_0}$, is inversely proportional to the specific gravity of the gas. If the specific heat is referred

(1) Annual Report for 1847 and 1848, I, 65.

(2) Annual Report for 1847 and 1848, Ibid.,

to the unit of volume and not to the unit of weight, it is only necessary to divide c and c' by v_0 and we obtain

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$$\gamma' - \gamma = A \frac{p_0}{a + t_0},$$

in which nothing more appears, which would depend on the especial nature of a gas: (third consequence) the difference of the specific heats of the unit of volume is equal for all gases.—The quotient

$\frac{\gamma'}{\gamma} = k$ is hence found:

$$k = 1 + \frac{A}{\gamma} \cdot \frac{p_0}{a + t_0}$$

consequently (fourth consequence) the excess of this quotient over unity is inversely proportional to the specific heat under a constant volume for the unit of volume, as was very approximately shown by Dulong's(1) experiments.

If c , which is generally to be considered a function of the temperature, is assumed to be constant, c' and $\frac{c'}{p} = k$ are also constant, as Poisson assumed from the experiments of Gay-Lussac and Welter, and made it the foundation of his investigations concerning gases.

If in equation [5] Q and c are assumed constant, we have

$$\frac{AR}{c} (a + t) = v^{k-1} (a + t) = \text{const} : \text{ and } \frac{a + t}{a + t_0} = \left(\frac{v_0}{v} \right)^{k-1},$$

whence finally $\frac{p}{c_0} = \left(\frac{v_0}{v} \right)^k$ can be deduced, relations between temperature volume and pressure, which Poisson has developed for the same case.

If in equation [5] t is assumed constant, we have

$$dQ = AR \cdot \frac{(a + t)}{v} dv \quad [6]$$

and, integrating and determining the constant,

$$Q - Q_0 = AR (a + t_0) \log \frac{v}{v_0}$$

that is (fifth consequence) if a gas changes its volume without changing its pressure, the quantities of heat developed or absorbed by it are in arithmetical progression, while the volumes form a geometrical

(1) Ann. Ch. Phys. [2] XLI; Pogg. Ann. XVI, 199 and 438.

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progression. — If $\frac{p_0 v_0}{a + t_0}$ is substituted again for R , we have $Q - Q_0$

$= A p_0 v_0 \log \frac{v}{v_0}$; and if the consideration is referred to equal volumes of gas, we obtain not only Dulong's law (sixth consequence) that all gases develop or absorb an equal absolute quantity of heat when equal volumes of them are taken at equal temperatures and under equal pressures, and they are then compressed or expanded to equal fractions of this volume, but the above equation says also (seventh consequence) that this quantity of heat is independent of the temperature at which this change of volume takes place, and (eighth consequence) that if the original pressures are unequal in the different cases, the quantities of heat are proportional to these pressures.

Clausius returns now to Carnot's principle, and is of opinion that it may be so far adopted as this, that we may assume that with the passage of a certain quantity of heat from the body A , whose temperature is t , to the body B , whose temperature is τ , under the most favourable circumstances, that is when only bodies of equal temperature touch one another, is always connected a mechanical effect the ratio of which to that quantity of heat is a function of the temperature only. In the process from which equation [2] for permanent gases was deduced, the quantity of heat carried over was $\left(\frac{dQ}{dv}\right) dv$, neglecting higher terms; the mechanical effect produced was

$$\frac{R dv dt}{v}, \text{ and therefore } \frac{R \frac{dv dt}{v}}{\left(\frac{dQ}{dv}\right) dv} = \frac{1}{C} dt \text{ or } \left(\frac{dQ}{dv}\right) = \frac{RC}{v} \quad [7],$$

in which C is a function of the temperature; in the same manner we obtain for vapours at their maximum density

$$r = C (s - \sigma) \frac{dp}{dt} \quad [8].$$

By comparing equations [6] and [7], a nearer determination of the form of C is obtained, namely $C = A (a + t)$, and the values of C calculated by Clapeyron and Thomson in an entirely different manner agree very well with this. Both indeed made use of equation [8], but Clapeyron calculated C for the boiling-points of ether, alcohol, water, and oil of turpentin, while Thomson calculated it only for the vapour of water between the temperatures 0° and 230° , on the assumption that the vapour at its maximum density followed the law of Mariott and Gay-Lussac. If the value of C at $35^\circ.5$, the boiling-point of ether, is taken for the unit, we have for C according to the three modes of calculating it

Temperature.	C according to Clapeyron.	C according to Thomson.	According to Clausius $C = A(a+t)$.	Mechanical theory of heat.
35.5	1.00	1.00	1.00	
78.8	1.13	1.12	1.14	
100.0	1.22	1.17	1.21	
156.8	1.27	1.31	1.39	

The agreement of these numbers, which considering the uncertainty of the fundamental data is as close as could be expected, Clausius considers as a strong confirmation of the two adopted principles, and the secondary hypothesis thereto added.

Clausius shows farther that, if in [8] C is replaced by $A(a+t)$, and the laws of Mariott and Gay-Lussac assumed to be correct for vapours at their maximum density, and consequently $ps = R(a+t)$, an easy integration leads to the expression

$$\log \frac{p}{p_1} = \frac{r(t-100)}{AR(a+100)(a+t)}$$

where p_1 is the tension of the vapour at 100° and σ is neglected as small compared with s .

Putting $t-100=\tau$, $a+100=\alpha$ and $AR(\bar{a}+100)=\beta$ we have

$$\log \frac{p}{p_1} = \frac{\beta\tau}{\alpha+\tau}$$

a formula which has already been found empirically by many physicists as well suited for the calculation of tensions, although it can by no means be considered as having a theoretical foundation, since arbitrary hypotheses have been introduced.

The laws of Mariott and Gay-Lussac give

$$Aps \frac{a}{a+t} = ARa,$$

in which the right-hand side of the equation is constant, and as a close approximation s may be replaced by $s-\sigma$. But from [8] we have:

$$Ap(s-\sigma) \frac{a}{a+t} = \frac{ar}{(a+t)^2 \frac{1}{p} \frac{dp}{dt}} \quad [9]$$

and the deviation from those two laws may be here manifestly seen.

Since Regnault(1) found the latent heat of steam $\lambda = 606.5 + 0.305 t$, moreover

$$c = 1 + 0.00004 \cdot t + 0.0000009 \cdot t^2,$$

and since from the signification of λ it $= r + \int_0^t dt \cdot c'$, we have

$$r = 606.5 - 0.695 t - 0.00002 t^2 - 0.0000003 \cdot t^3.$$

(1) Annual Report for 1847 and 1848, I, 65.

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From this, and by means of Regnault's original observations of tensions, Clausius has calculated the values of the right-hand side of equation [9] for temperatures from -15° to $+225^{\circ}$, and then proposed for it a formula of interpolation, according to which the values between those limits of temperature decrease constantly from 30.61 to 26.32.—According to the laws of Mariott and Gay-Lussac, it was necessary that

$$\frac{ps}{ps_0} = \frac{a+t}{a}, \text{ consequently } \frac{d}{dt} \left(\frac{ps}{ps_0} \right) = \frac{1}{a} = 0.003665;$$

the interpolation formula in question however gives, instead of this, the following values of this differential quotient:

for	0°	50°	100°	150°	200°
"	0.00342	0.00319	0.00235	0.00231	0.00149

These values are all less than the coefficient of expansion of air, but they apply, as Clausius remarks, to the case where at the same time with the heating, the pressure increases in so great a ratio that the vapour remains at its maximum density. When carbonic acid is increased in temperature from 0° to 24.5° , and there is a simultaneous increase of pressure from 1^m to 2^m , the mean coefficient of expansion is found to be 0.00333, the smaller values obtained for steam at its maximum density may appear therefore less strange.

If the theoretical density of steam 0.622 is assumed as holding for σ , we find, taking account of the first-mentioned deviation from the laws of Mariott and Gay-Lussac, for the following temperatures the values of the density d which stand under them:

t	0°	50°	100°	150°	200°
d	0.622	0.631	0.645	0.666	0.698

If equations [4] and [8] are combined, we obtain

$$c \frac{dr}{dt} + c - \frac{r}{a+t} = h = 0.305 - \frac{606.5 - 0.695t - 0.00002t^2 - 0.0000003t^3}{273+t}$$

and thence

t	0°	50°	100°	150°	200°
h	1.916	1.465	1.133	0.879	0.676

From the manner in which the constant A is introduced into equations [2] and [4], it follows that $\frac{1}{A}$ is the work-equivalent for the unit of heat (the mechanical equivalent of heat).—From the equation $c' = c + AR$ we find $\frac{1}{A} = \frac{kR}{(k-1c')}$, and by introducing the value of $c' = 0.267$ (de la Roche and Berard), $k = 1.421$ (Dulong)

and $R = \frac{p_0 v_0}{a + t_0} = 29.26$, we find $\frac{1}{A} = 370$, that is, by the expenditure of the quantity of heat which raises the temperature of 1 kilogr. of water from 0° to 1° , 370 kilogr. can be raised to the height of 1 metre. Yet, on account of the uncertainty of the data, this determination is little to be depended on.—From the equation $r = A(a + t)(s - \sigma) \frac{dp}{dt}$ obtained for vapours, by putting the temperature 100° , the corresponding atmospheric pressure 10333 kilogr. and $s = 1.699$, we find $\frac{1}{A} = 437$. Assuming, however, the specific gravity of steam at 100° to be, not $= 0.6235$ with Gay-Lussac, but $= 0.645$ as it was found above, we have $s = 1.638$ and $\frac{1}{A} = 421$, which most nearly agrees with Joule's result.

J. Thomson(1), in a paper on the mechanical theory of heat, in which he set out from Carnot's principle, has drawn the conclusion that the point of solidification of fluids cannot be independent of the pressure, and for instance, that the freezing-point of water must sink about $t = n \cdot 0.00075$ (C.) by the addition of n atmospheres to a pressure of one atmosphere.—W. Thomson(2), with the help of one of Oersted's water-compressing apparatus, which he filled with water and clear pieces of ice, and in which he then immersed a manometer and an ether-thermometer, has found this conclusion proved and confirmed. Pressures of 8.1 and 16.8 atmospheres produced a sinking of 0.059 and 0.129 , while the preceding formula gives 0.061 and 0.126 .

A confirmation for a wider range has been given by Bunsen(3). He attached to a board, near one another, two thick glass tubes of small internal bore, filled with mercury; both contained at the lower end small quantities of the substance whose point of solidification was to be observed, both were drawn out above into a fine capillary tube, which contained air in its upper calibrated part; but the one was open, the other closed, so that the air in the latter served for manometrical measurements. By immersion in water, whose temperature was somewhat above the melting-point of the substance, a pressure was produced in the closed tube which caused congelation in this earlier than in the open tube. Bunsen obtained the following results:

(1) Edinb. Trans. XVI.

(2) Phil. Mag. [3] XXXVII, 123; Pogg. Ann. LXXXI, 163; Arch. Ph. Nat. XV, 221; Proceedings of the Roy. Soc. of Edinb. 1850, 267; Inst. 1850, 415.

(3) Pogg. Ann. LXXXI, 562; Berl. Acad. Ber. 1850, 465; J. Pr. Chem. LM, 342.

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With spermaceti		With paraffin	
Pressure in atmospheres.	Congeealing-point.	Pressure in atmospheres.	Congeealing-point.
1	47 ⁰ .7	1	46 ⁰ .3
29	48 ⁰ .3	85	48 ⁰ .9
96	49 ⁰ .7	100	49 ⁰ .9
141	50 ⁰ .5		
156	50 ⁰ .9		

Bunsen considers the temperatures accurate to 0⁰.1, the measure of the pressure, on the contrary, possibly inaccurate to the extent of some atmospheres.

Clausius's(1) shows how, from the equation

$$r = A (a + t) (s - \sigma) \frac{dp}{dt},$$

which is applicable to the passage of fluids into the solid condition, if s and σ are taken to represent the volumes of the unit of weight of the solid and fluid body, and at the same time the magnitude $\frac{dt}{dp}$ is taken as negative, since in this case heat is disengaged instead of becoming latent, not only the preceding results in general follow, but even a consistent numerical value; put $t=0$, $\frac{1}{A} = 423.55$ (Joule), $a=273$, $\sigma=0.001$, $s=0.001087$ and express p in atmospheres, then we have $\frac{dt}{dp} = -0.00733$, while Thomson found -0.0075 .—Clausius,

by combining the equation $\frac{dr}{dt} + c - h = A (s - \sigma) \frac{dp}{dt}$ with the previous one, obtained $\frac{dr}{dt} = c - h + \frac{r}{a + t}$, an equation which expresses the change of the latent heat of melting with the temperature of congelation. In this it is true that c and h represent the difference of the specific heats for the case where, conformably to the above equation, the pressure changes as well as the temperature, yet we may with great approximation take for them the difference of the specific heats in the usual sense, and we then have for water, where $c=1$ and h (according to Person) $=0.48$, $\frac{dr}{dt} = 0.52 + 0.29 = 0.81$, so that consequently for each degree the freezing-point of water is lowered by pressure, the latent heat decreases by 0.81.—The diminution 0.52 appears even when the freezing-point is lowered only by protecting

the water from all shaking(1). The part 0.29 on the other hand corresponds to the external work performed by the pressure.

Rankine in his mathematical treatment has adopted the same principle as Clausius, but has therewith, as it appears to us, unnecessarily gone back to a hypothetical ground, in regarding the mechanical nature of heat as consisting in a rotatory motion of atomic atmospheres, and thence deducing the first equations. The limits prescribed to this Report prevent us entering on Rankine's paper, and that the more because this investigator has arrived at the same results as Clausius obtained independently of such highly doubtful hypotheses. It may, nevertheless, be considered a pleasing confirmation of the correctness of the new mode of regarding the phenomena of heat, that two investigators have arrived at like conclusions independently of one another, and by methods not altogether similar.—The mechanical equivalent of heat Rankine found to be $=381.64$, and considered that the cause of the deviation from Joule's result was to be sought for in the loss of power, which occurred in the experiments of the latter. More recently, however, Rankine(2) retracts this opinion, and thinks rather that the principal cause of the deviation of his result lies in the inaccuracy of the value of the apparent specific heat of air under a constant pressure ($=0.2669$) determined by De la Roche and Berard, which he made use of. Taking Joule's heat-equivalent as a starting-point, this value is found to be $=0.2404$.—Rankine also arrived at the first consequence cited in page 28, which does not altogether agree with the usual ideas.—He finds, farther, in exact agreement with Regnault's(3) empirical law, that the total heat of vaporization, provided we may consider the vapour as a true gas, increases nearly uniformly with the temperature, and the co-efficient of increase with the temperature is always nearly equal to the apparent specific heat of the vapour under a constant pressure $=k(1+N)=0.194.1.57=0.305$, where $k=0.194$ is the true specific heat of the vapour, that is, that quantity of heat which, when the temperature is raised 1° , is expended in this only, and not in the production of any internal or external mechanical effect.—In the last division of his paper Rankine treats of the theory of the steam-engine, showing what alterations must be made in the practical formulæ of Pambour(4) to make them agree with the fundamental laws of the theory of heat.—He shows that in the most favourable case not more than the sixth part of the quantity of heat generated can be converted into mechanically useful power, while the five-sixths pass over into the condenser or the atmosphere;

(1) Already Person conjectured that the latent heat of water was diminished in this manner, (Compt Rend XXIII, 336). Comp. p. 38.

(2) Pogg Ann. LXXXI, 175.

(3) Annual Report for 1847 and 1848, I, 65.

(4) Nouvelle Théorie des Machines à Vapeur.

Mechanical theory
of heat

usually, according to Rankine, only one twenty-fourth of the heat generated is usefully expended.—Two tables are appended to the paper for calculating easily the pressure of vapour from its volume, and the effect of the expansion.

W. Thomson(1) considers that the circumstance that the steam issues dry from the valves of the high-pressure engine, since the hand can be held in the steam without danger, is in opposition to the law enounced by Clausius and Rankine, according to which steam is partially condensed by expansion.—He considers that the only possible solution of this contradiction is in the supposition that in issuing out heat is developed by friction, which is in accordance with Joule's experiments. We shall return more at length to this subject in our next year's Report.

Expansion.—Militzer(2) has communicated experiments on the expansion of mercury by heat. He based these on the principle already previously applied to this purpose, viz. to determine the length of a mercurial column in a barometer that has equal weight with the pressure of the atmosphere, with the mercury at a lower and at a higher temperature. He made twenty-nine observations in which the colder mercury had a temperature of from 2° to 4° , and the hotter from 19° to 23° , and the differences of temperature amounted to from 16° to 20° : the values which he calculated for the co-efficient of expansion of mercury for 1° (its volume at 0° being put = 1) lie between 0.00016497 and 0.00018333, and give the mean value 0.00017405 \pm 0.00000082(3). Militzer has calculated tables for the reduction of heights of the barometer to 0° , based on this co-efficient of expansion.

According to J. Pierre(4) isomeric fluids in general contract unequally in cooling for equal degrees below their boiling points, and only the acetate of methyl and the formiate of ethyl form an exception, inasmuch as they contract equally from their boiling-point. The more extended proofs of this opinion were first published in 1851, and we shall return to it in our next year's Report.

Berthelot(5) has observed that a fluid in a closed space at a definite temperature, can fill a greater space than properly belongs to it for this temperature. If a glass tube drawn out fine at its open end is filled with water at about 28° , air introduced into the thin drawn-out part by cooling down to 18° , the point sealed, and the tube again

(1) Phil. Mag. [3] XXXVII, 386; Pogg. Ann. LXXXI, 477.

(2) Pogg. Ann. LXXX, 55.

(3) Comp. Regnault's determination in Annual Report for 1847 and 1848, I, 52.

(4) Compt. Rend. XXXI, 378; Instit. 1850, 289.

(5) Ann. Ch. Phys. [3] XXX, 232; Pogg. Ann. LXXXII, 330; Compt. Rend. XXX, 819 (in abstr.); Instit. 1850, 202; Ann. Ch. Pharm. LXXVI, 129.

heated to 28° , the enclosed air is gradually absorbed by the water; the water now fills the whole space of the tube, and continues to do so also if the tube is again cooled to 18° or still lower, but by the smallest shaking the air escapes out of the water, and the latter occupies the space corresponding to the lower temperature. The phenomenon, that the water continues to fill at the lower temperature the same space as at the higher, is only exhibited if the air has been completely absorbed; otherwise, each cooling is accompanied by an enlargement of the remaining bubble of air. Berthelot repeated this experiment with the most different kinds of fluids with the same result; mercury alone did not absorb the air, however great the pressure, at least not completely. Water and ether exhibited also, without the presence of air, this phenomenon of continuing to fill a greater space, which Berthelot calls "constrained expansion," and he considers it is due to the adhesion of the fluid to the glass.

Thermometry.—S. M. Drach(1), to avoid as much as possible the use of negative temperatures, has proposed to take as the zero-point the temperature $-40^{\circ}\text{ F.} = -40^{\circ}\text{ C.}$ or $-38^{\circ}\text{ F.} = 38^{\circ}\cdot8\text{ C.}$, and to divide the interval between this temperature and the boiling-point of water into 1000 degrees.

A. d'Abbadie(2) has drawn attention to the fact that the reduction of English citations of temperature in degrees of Fahrenheit to the centigrade thermometer accurately considered, is not effected by the formula $C = \frac{(F. - 32) 100}{180}$, inasmuch as in the English thermometers the boiling-point is determined for a barometric pressure of 30 Eng. inches = 761·99 millim.: in the French and others for 760 millim., and a centigrade thermometer of the latter kind at a pressure of 30 Eng. inches will show $100^{\circ}\cdot073$ as the boiling-point of water. Besides this, he takes account of the difference of gravity in Paris and in London, and arrives on the whole at the formula of reduction for thermometers which are graduated in London according to Fahr., for a boiling-point under a pressure of 30 inches, and in Paris as centigrade thermometers for a boiling-point under a pressure of 760 millim.

$$C = \frac{(F. - 32) \times 100\cdot08066}{180}$$

J. Adie(3) has communicated observations on the displacement of the zero-point in the mercurial thermometer. He found this in general equally great for such thermometers as were sealed perfectly free of air, and for such as were sealed containing some air; the elevation of

(1) Phil. Mag. [3] XXXVI, 65.

(2) Compt. Rend. XXX, 570; Instit. 1850, 156.

(3) Edinb. New Phil. Journ. XLIX, 122.

Thermo-
metry

the zero-point was also equally great for these thermometers which were kept for eight days at 100° before filling, and for those which had been filled without this preliminary heating; it was accelerated by exposing the thermometer for some time (eight days) to 100° ; the elevation of the zero-point amounted in fourteen months to from $0^{\circ}\cdot36$ to $0^{\circ}\cdot50$; the zero-point fell after this time instantaneously about $0^{\circ}\cdot2$ or $0^{\circ}\cdot3$, when the point of the thermometer was broken and air was able to enter into the tube(1); in thermometers which are filled with alcohol, no displacement of the zero-point appears to occur.

Registering Thermometer.—Kreil(2) has described a self-registering thermometer in which the expanding body is a system of zinc rods; Peytal(3) has proposed the construction of such a thermometer in which the expanding body is a Breguet's metal thermometer.

Specific Heat: Melting: Latent Heat of Melting.—An investigation of Person concerning the specific heat of the solutions of salts, and the latent heat of solution is as yet only published in abstract(4). In the dissolving of salts, the change of temperature is regulated by the chemical affinity of the dissolving medium for the salt, the passage from the solid to the fluid state, the quantity of the dissolving medium and the temperature. 1 grm. of nitrate of potassa requires 49 units of heat to melt it alone; 69 units of heat become latent when it is dissolved in 5 grms. of water, 80 when it is dissolved in 20 grms. The mere dilution of a solution of salt can produce a lowering of the temperature, which consequently does not depend alone on the passage of the salt from the solid to the fluid state. In salts whose affinity for water is great, the absorption of heat in dissolving may be less than in melting: chloride of calcium requires 41 units of heat to melt it alone and only 20 to dissolve it. Phosphate of soda absorbs equal quantities of heat in melting and in dissolving. As Graham has already remarked, the heat absorbed in the dissolving of a salt is different at different temperatures. Nitrate of potassa absorbs 80 units of heat when dissolved in water at 20° , 86 when dissolved in water at 0° . Chloride of sodium, when dissolved in 7 parts of water of 70° would produce no lowering of temperature at all, in water of more than 70° even an elevation of temperature. Person found the specific heats of the solutions of salts constantly less than the values calculated from the specific heats of their component parts (comp. Andrews, pag. 21).

With reference to the change of the melting-point by pressure, see page 33.

(1) A fact which had been observed at an earlier period, (by Egen, for instance, Pogg. Ann. IX, 349).

(2) Wien. Acad. Ber. 1850, Juni, 39.

(3) Instit. 1850, 300.

(4) Compt. Rend. XXXI, 566.

Provostaye and Desains and Regnault had recently found the latent melting heat of ice very nearly = 79. According to Person(1) this number expresses the quantity of heat which is necessary to change ice at 0° into water, but not the whole latent melting heat, of which, according to Person, a part has been already absorbed somewhat under 0° , between -2° and 0° . Regnault himself obtained greater values for the heat of melting, the colder the ice was which he employed in his experiments. Person has now determined more accurately the specific heat of ice (previously found by him(2) = 0.502) to be = 0.48 for temperatures between -21° and 2° , by mixing ice and salt-water (for the solution of 368.8 chloride of sodium in 1131.2 water, he found the specific heat 0.786); in six experiments he found the heat becoming latent in the melting of ice, which in the beginning of the experiment was cooled down to from -2° to -21° , to be from 79.9 to 80.1, in the mean = 80.0.—J. Hess(3) made a great number of experiments, by the method of mixing, with ice variously cooled and water, and found from them the specific heat of ice = 0.533, and its latent melting heat = 80.34.

Specific
heat:
melting
latent heat
of melting

Boiling: Relations between Composition and Boiling-points.—Groshans(4), continuing his previous researches(5), has sought to give new proofs of the laws then established, and has communicated new remarks on the volumes and densities of fluid and gaseous bodies. According to him, the densities, at the same temperature, of fluids which have nearly the same boiling-point, are in simple ratios, and the ratio of the densities of the fluids is in a simple ratio to the ratio of the densities of the vapours; bodies show in general, in passing from the gaseous to the fluid state simple ratios in the contractions; the contractions of different fluids with nearly the same boiling-points are equal for the same depression of temperature. The proofs given by Groshans are not sufficiently numerous and too little free from arbitrary hypotheses, to be considered satisfactory.

H. Schröder(6) has, also in continuation of his previous researches(7), sought to determine more accurately the influence of carbon, hydrogen and oxygen on the boiling-point, by comparing the boiling-points of carbo-hydrogens and ethers, carbo-hydrogens and acids, ethers with one another, carbo-hydrogens with one another, acids with one another. He assumes that the influence of these elements may be variable, but calculates, however, what he calls

(1) Ann. Ch. Phys. [3] XXX, 73; Ann. Ch. Pharm. LXXVI, 97; Compt. Rend. XXX, 526 (in abstr.); Instit. 1850, 137.

(2) Annual Report for 1847 and 1848, I, 58.

(3) Petersb. Acad. Bull. IX, 81.

(4) Pogg. Ann. LXXIX, 290; LXXX, 298.

(5) Annual Report for 1849, III, 26.

(6) Pogg. Ann. LXXIX, 34; Ann. Ch. Pharm. LXXVI, 176.

(7) Pogg. Ann. LXII, 184, 337; LXIV, 96, 367; LXVII, 45.

Boiling :
Relations
between
composi-
tion and
boiling-
points

the mean or normal influence of the elements. According to this, a boiling-point higher by $28^{\circ}8$ would correspond to the addition of O_2 or of C_2 , a boiling-point lower by $7^{\circ}2$ to an addition of H_2 . According to Schroder, the influence of the elements on the boiling-points are in simple ratios to one another and to the influences of the combined elements; the influence of C_2 or O_2 (in the ethers) would be $= 28^{\circ}8 = 4 \times 7^{\circ}2$, of O_4 in the acids $= 14^{\circ}4 = 2 \times 7^{\circ}2$, of $C_2O_2 = 57^{\circ}6 = 8 \times 7^{\circ}2$, of $C_2O_4 = 86^{\circ}4 = 12 \times 7^{\circ}2$, of $C_4H_2 = 50^{\circ}4 = 7 \times 7^{\circ}2$, of C_2H_2 in the organic acids $C_{2n}H_{2n}O_n = 21^{\circ}6 = 3 \times 7^{\circ}2$, of C_2H_2 as a difference in the composition of the corresponding combinations, of methyl and ethyl probably $= 14^{\circ}4 = 2 \times 7^{\circ}2$. Perhaps also the natural law of the simple ratios in the influences on the boiling-points may hold so that these influences are always multiples, not of $7^{\circ}2$, but of $3^{\circ}6$. Schroder gives the following formulæ for the boiling-points of

$$\text{Carbo-hydrogens } n \quad 28 \cdot 8 \frac{c}{2} - 7 \cdot 2 \frac{h}{2} - 72 \cdot 8$$

$$\text{Ethyl-ethers } . \quad 28 \cdot 3 \frac{c+o}{2} - 7 \cdot 2 \frac{h}{2} - 72 \cdot 8$$

$$\text{Methyl-ethers} \quad 28 \cdot 8 \frac{c+o}{2} - 7 \cdot 2 \frac{h}{2} - 65 \cdot 6$$

$$\text{Amyl-ethers} \quad 28 \cdot 8 \frac{c+o}{2} - 7 \cdot 2 \frac{h}{2} - 80 \cdot 0$$

$$\text{Acids and alcohols : } 28 \cdot 8 \frac{c+o}{2} - 7 \cdot 2 \frac{h}{2} + 13 \cdot 6$$

if the formula for one atom (the volumes of vapour) of a compound is expressed by $C_c H_h O_o$. The formulæ do not hold for all substances of the foregoing classes, and even for those whose boiling-points, according to Schroder, are theoretically determinable from the formula, the true boiling-point may be different from the calculated one by $\pm 7^{\circ}2$; $\pm 14^{\circ}4$; $\pm 21^{\circ}6$; $\pm 28^{\circ}8$, &c.—H. Kopp(1) has shown that the attempt to determine the influences of the elements on the boiling-point resolves itself into finding the unknown quantities in an indeterminate problem; that if only those substances which are really comparable are compared, there are always more unknown quantities in the problem than equations of condition, but in particular there are exceedingly many unknown quantities if it be assumed with Schroder that the influence of the same element may be of different magnitudes in different combinations; Kopp has farther shown that the theory put forward by Schroder, together with the numbers contained in it, is the result of an arbitrary and illogical application of an incorrect principle, and that the numbers themselves are to be considered as accidental or arbitrary.

(1) Pogg Ann. LXXXI, 374; Ann. Ch. Pharm. LXXVI, 180 (in abstr.)

Tension of Vapours.—Soret(1) communicates the results of some more recent investigations of Regnault concerning the tensions of vapours in mixtures of several vapours, or of vapours and gases, from which it follows that the law of Gay-Lussac, by which the tension of a mixture is said to be equal to the sum of the tension of its component parts, has limitations, and also under what circumstances this takes place.

Tension of
vapours.

If the fluids do not dissolve in one another at all, or only to a very small extent, the deviations from the law stated are inconsiderable, as the following numbers prove.

Temperature.	Tension of vapour of water.	Tension of vapour of fluid mixed with it.	Sum of tensions.	Observed tension of mixture.	Difference.
BENZOL AND WATER:					
10°·10	9·23 ^{mm} .	45·00 ^{mm}	56·23 ^{mm}	54·92 ^{mm}	+ 1·31 ^{mm}
22°·53	20·30 „	85·50 „	105·80 „	104·28 „	+ 1·52 „
BISULPHIDE OF CARBON AND WATER:					
8°·85	8·49 ^{mm}	189·7 ^{mm}	198·19 ^{mm}	196·81 ^{mm}	+ 1·38 ^{mm}
38°·35	50·26 „	585·0 „	635·26 „	634·60 „	+ 0·66 „
CHLORIDE OF CARBON AND WATER:					
7°·79	7·90 ^{mm}	52·7 ^{mm}	60·60 ^{mm}	63·49 ^{mm}	— 2·89 ^{mm}
44°·59	69·91 „	257·0 „	326·91 „	328·38 „	— 1·47 „

Of such fluids as combine with one another in considerable quantity but not in all proportions, Regnault could only investigate one mixture of vapours, that of ether and water; he found:

Temperature.	Tension of vapour of water.	Tension of vapour of ether.	Sum of tensions.	Observed tension of mixture.
15°·56	13·16 ^{mm}	361·8 ^{mm}	374·96 ^{mm}	362·95 ^{mm}
24°·21	22·47 „	510·0 „	532·47 „	510·08 „
33°·08	37·58 „	711·1 „	748·68 „	710·02 „

It appears from this, that the tension of the mixture is scarcely different from that of ether alone.

In the last conceivable case, when the fluids combine with one another in every proportion, Gay-Lussac's law no longer holds at all; the tension changes besides with the proportion in which the vapours are contained in the mixture; it is generally less than the tension of the vapour of the more volatile substance, and greater than the tension of the vapour of the less volatile, so that it seems as if the molecular attraction between the two fluids rendered the vaporization difficult.

The tension of vapours in a space filled with gas is certainly not much different from the tension in a vacuum. The accurate measurement of the small difference has considerable difficulties, because the

Tension of
vapours.

maximum tension in a space filled with gas is only attained very slowly, and the glass sides begin to condense vapour on their surfaces before the maximum has come on. Regnault found the tension of the vapours of water, ether and some other fluids somewhat less in air than *in vacuo*. For ether the difference amounted to 8 or 10 millim. Yet a dew of fluid ether was deposited on the sides of the glass from 20 to 25 millim. below the tension of saturation.

Tension of Steam.—Curr(1) has established the following formula for the connection between the tension and the temperature of steam :

$$F = \left(\frac{t}{100} \right)^4$$

in which F is the tension expressed in atmospheres, and t the temperature in degrees of Celsius. Since the derivation of the formula is unintelligible to us, and it does not agree at all with the known results of observation, we can say nothing farther about it.

J. H. Alexander(2) has calculated from his formula already previously communicated(3) a table which gives the tension of the vapour of water, measured by a mercurial column in English inches, at intervals of 5° from 0° to 30° Fahrenheit, and from 32° F. to 365° F. at intervals of one degree.

V. Pierre(4) has invented a new instrument, by which, he says, the amount of moisture in the air may be measured without its being necessary to rely on the tables of tensions of vapour of water *in vacuo*, or on the truth of Dalton's law. The instrument consists essentially of a cylinder with a double metal covering, in which the moist air is received, and through the top of which a siphon-barometer and a thermometer reach into the inner space. The cylinder has a double bottom; the space between the two bottoms is filled with chloride of calcium, and at first is hermetically separated from the upper portion of the cylinder. After the barometer has been read off, a communication between the lower and upper spaces is opened by turning a disc, and, as Pierre states, the moisture is at once completely absorbed without a sensible change of temperature. The barometer then gives the pressure of the dry air.—Pierre objects to the cylinder being made of glass, because of the hygroscopic properties of this substance. But he must then assume the change in the height of the barometer equal to double the change in its outer leg. The way in which Pierre expects to be able to avoid this most dubious assumption is unintelligible to us.

(1) Phil. Mag. [3] XXXVII, 304; Instit. 1851, 21.

(2) Sill. Am. J. [2] VII, 361.

(3) Annual Report for 1847 and 1848, I, 72.

(4) Wien. Acad. Ber. 1850, Juni, 63.

In the years 1845—49 Wisse(1) measured the boiling-point of water in the neighbourhood of the Equator at various heights above the level of the sea, partly with Regnault's hypsometric apparatus, partly with a particular larger boiler, and at the same time observed the height of the barometer. The results were compared by Regnault(2) with his table(3) of the tensions of water at different temperatures. The agreement was very good, as the following examples show :

Stations.	Boiling-points.	Height of barometer according to Wisse.	Tension according to Regnault.	Difference.
Guayaquil	99 ^o ·70	752·10 ^{mm}	751·87 ^{mm}	+ 0·23 ^{mm}
Mindo	95 ^o ·93	656·26 „	655·85 „	+ 0·41 „
Quito	90 ^o ·91	544·18 „	543·93 „	+ 0·25 „
Pichincha	85 ^o ·16	435·81 „	435·78 „	+ 0·03 „
Its summit	84 ^o ·83	430·29 „	430·15 „	+ 0·14 „

Thermobarometric Measurements of Heights.—Kupffer(4) gives a formula for Regnault's hypsometric apparatus (thermobarometer). If t is the number of centigrade degrees which the boiling-point of water is under 100°, z the height of the station in metres above that where the boiling-point of water is 100°, then approximately, $z=300t$; where the temperature of the air is assumed to be 9°·3. The following table shows the degree of agreement with the accurate barometric formula :

t	Height in metres :		t	Height in metres :	
	approximate.	accurate.		approximate.	accurate.
1	300	295	4	1200	1196
2	600	594	5	1500	1500
3	900	894			

Beyond 1500 metres the formula is no more applicable. If the mean height of the barometer at the sea is higher than 760 millim., about 10 metres must be added to the height z for each additional millim.

Rain-gauge and Hygrometer.—Legeler(5) describes a wind- and rain-gauge with which he has already made observations for several years at Sans-souci, and which does the following things; 1. It expresses the quantity of water in the precipitation from the atmo-

(1) Ann. Ch. Phys. [3] XXVIII, 118.

(2) Ann. Ch. Phys. [3] XXVIII, 123; Pogg. Ann. LXXX, 578.

(3) Ann. Ch. Phys. [3] XIV, 206.

(4) Petersb. Acad. Bull. VIII, 327; Pogg. Ann. LXXX, 579; Arch. Ph. Nat. XV, 308.

(5) Pogg. Ann. LXXX, 364; Berl. Acad. Ber. 1850, 146.

Rain-
guage and
hygrome-
ter.

sphere in thousandths of a line, and collects it for each principal direction of the wind in a separate cylinder; 2. It gives the directions of the wind accurately and indicates the lulls of wind that take place; 3. If the wind be changed through all the points of the compass, the apparatus shows in what direction this has taken place.

Appold(1) has invented an hygrometer, which by a change of a quarter of a degree in the hygrometric state of the atmosphere opens a valve out of which water is poured on heated tubes till by the vaporization of this the previous hygrometric state of the air is restored, when the valve is closed.

Condensation of Gases.—Bunsen(2) made use of the expansion caused by heat in water in a vessel, in which a fine small tube filled with gas was placed, to produce a strong pressure on this gas. Berthelot(3) has applied the same principle to condense small quantities of gas. A strong glass tube closed at one end, drawn out at the other end, is filled perfectly with mercury (for the condensation of ammoniacal or carbonic acid gas) or with sulphuric acid (for the condensation of chlorine), the point of it is introduced into a tube, through which a stream of the gas to be condensed is passing; by cooling the tube, gas enters into the drawn-out end, and the point is then sealed: by heating, the gas is compressed and condensed (frequently not until a higher temperature is attained than that at which the tube was previously completely filled with mercury) to a fluid. If the greatest strength of glass possible has been left to the part of the tube drawn out, the tube eventually splits by the giving way of the glass at its wider part, without explosion. — Berthelot tried in vain to condense nitric oxide, carbonic oxide and oxygen.

Conduction of Heat.—Senarmont(4) communicates as an addition to his paper on the conduction of heat in crystals(5), that a plate of tourmaline of a sea-green colour cut parallel to the axis, 32 millim. long, 28 millim. broad, and 1.75 millim. thick, gave a heat ellipse, whose minor axis was in the direction of the principal crystallographic axis, and was in the ratio of 1 : 1.27 to the major axis. Tourmaline, in consequence of its thermal properties, may be classed as a repulsive crystal along with idocrase, sapphire and specular iron.

Change of the Conducting Power by Magnetism.—Maggi(6) has shown that the conducting power for heat of soft iron undergoes a

(1) Inst. 1850, 398.

(2) Pogg. Ann. XLVI, 97.

(3) Ann. Ch. Phys. [3] XXX, 237; Compt. Rend. XXX, 666 (in abstr.); Instit. 1850, 109; J. Pharm. [3] XVII, 442; Ann. Ch. Pharm. LXXVI, 131.

(4) Ann. Ch. Phys. [3] XXVIII, 279; Pogg. Ann. LXXX, 175.

(5) Annual Report for 1847 and 1848, I, 76.

(6) Arch. Ph. Nat. XIV, 132.

change when the iron is magnetised. He made use of a circular plate of soft iron, to which the heat was communicated by hot steam, which flowed in a tube of plate iron through its centre. The plate was provided with a thin coating of wax, which Senarmont had employed in his experiments on the conducting power of crystals, and placed between the poles of a horse-shoe electro-magnet, yet without coming in immediate contact with it. In the equatorial direction, iron bars were brought near it, of the same magnitude as those of the magnet, to secure symmetry in every condition. The isothermal lines were circles when the electro-magnet was not in activity; but when the iron was magnetised they immediately changed into ellipses whose major axes were in the equatorial direction, and were to the minor axes in the ratio of 6.5. De la Rive(1) remarks that this result agrees with his own experience, according to which the particles of soft iron, when magnetised, separate from one another in the axial direction, and approach one another in the equatorial direction.

Change of
the con-
ducting
power by
magnet-
ism.

Radiant Heat.—Melloni(2) has in his work, *La Thermochrose*, given a full treatment of the theory of radiant heat in its present position. An abstract, which according to the object of this Report must be confined to the new facts and points of view, could only give an imperfect idea of this classical work. We therefore only add that the first section of the first part, which is all that has appeared at present, treats of the instruments employed for measuring radiant heat; the second section contains the investigation of various sources of heat; the third, the radiation of heat in air and *in vacuo*; the fourth and most important, finally, the investigations concerning the transmission of heat through solid and fluid media. De la Rive(3) has furnished an extended extract from the work in question.

Absorbing Power for the Rays of Heat.—Provostaye and Desains(4) have determined by three different methods the absorbing power of a series of bodies, and the result has come out that the absorption varies with the nature of the source of heat. The first method depends on this, that, if the temperature of a thermometer whose bulb is covered with the substance in question has become stationary under the influence of a constant source of heat, it receives as much heat in a unit of time as it gives off. If therefore the ratio of the rates of cooling is known, the absorbing power is also known. The thermometers were placed inside a blackened case, and the heat of the sun

(1) Arch. Ph. Nat. XIV, 134.

(2) *La Thermochrose, ou la Coloration Calorifique*, Première Partie, Naples, 1850.

(3) Arch. Ph. Nat. XIV, 177, 257.

(4) Ann. Ch. Phys. [3] XXX, 431; Compt. Rend. XXXI, 770; Instit. 1850, 385; Ann. Ch. Pharm. LXXVI, 182 (in abstr.)

Absorbing
power for
the rays of
heat.

or of a lamp was concentrated in a focus by a spherical lens near the thermometer-bulb. On the one hand, the heat which the source of heat receives back from the thermometer may, on account of the great difference of temperature, be neglected in comparison with that which it communicates to the thermometer, so that the heat received by the latter may be taken as simply proportional to the absorbing power of that substance with which the bulb is enveloped; since, on the other hand, the source of heat is proportionately of so small an extent, the cooling of the thermometer takes place exactly as if it alone were present in the enveloping case. The temperature at which the thermometer became stationary when covered with one of the substances to be tried was first approximately determined, then the rates of cooling corresponding to this and the neighbouring temperatures were determined, and then, in order to obtain the stationary point accurately, the temperature was raised somewhat above this point by means of a red-hot metal plate, and read off when it had returned to that point. The rate of cooling corresponding to this point could then be calculated accurately by interpolation. The comparison with lamp-black, whose absorbing power is considered as perfect and taken = 1, gave :

Absorbing power for the heat of a lamp.		Absorbing power for solar heat.	
Platinum-black . . .	1.00	White-lead . . .	0.19
Cinnabar . . .	0.285	Gold-leaf . . .	0.13
White-lead . . .	0.21	Silver-leaf . . .	0.075
Powdered silver . . .	0.21		
Gold-leaf . . .	0.04		

From theoretical considerations, which Provostaye and Desains prefixed to their paper, they deduced the consequence, which indeed at first sight appears a paradox, but is fully confirmed by experiment, that *in vacuo* a thermometer covered with gold-leaf under the influence of luminous rays must become more heated than if the bulb were covered with white-lead; although the former reflects 96 per cent of all incident heat, while the absorbing power of white-lead up to 150° , is equal to that of lamp-black. The reason is this, that the gold-leaf, as the preceding table shows, absorbs 5 times fewer rays of the heat of the lamp than the white-lead, but on that account also sends back 25 times fewer dark rays of heat.—In air, the ratio of the rates of cooling is only as 1.64 to 1, the absorbing power of the white-lead is therefore no longer compensated in this case; in fact, the two thermometers assume then nearly equal temperatures.

From the law that the absorbing power of bodies which do not sensibly disperse the heat is the complement of the reflecting power, Provostaye and Desains deduced the following results :

	Heat absorbed of:					Absorbing power for the rays of heat.
	the sun.	the moderator lamp.	Locatelli's lamp.	of the flame of alcohol, salted.	a copper plate at 400°.	
Steel	0.42	0.34	0.175	0.12	—	
Speculum metal	0.34	0.30	0.145	—	—	
Platinum	0.39	0.30	0.17	0.14	0.105	
Zinc	—	0.32	0.19	—	—	
Tin	—	0.32	0.15	—	—	
Brass	—	0.16	0.07	0.06	0.055	
Gold	0.13	—	0.045	—	0.045	
Very brightly polished silver plates	0.38	0.035	0.025	—	—	

The values are true for all angles of incidence from 0° to 75° . They are rather too great for the metals, for which all the dispersion could not be avoided.

From the equality of the radiating and absorbing powers Provostaye and Desains finally deduced the following values for a source of heat of 200° :

Silver	0.025	Copper	0.05
Gold	0.04	Platina	0.10

Transmissibility of the Rays of Heat.—Masson and Jamin(1) have investigated the transmissibility through various substances of the rays of as pure a solar spectrum as possible, principally with the view of determining whether the light- and heat-rays have such similar properties under these circumstances as to justify us in concluding that both sets of rays have a common cause.—They found that the rays of heat of all degrees of refrangibility between the extreme red and violet were transmitted equally completely by rock-salt, rock-crystal, alum, glass and water which are diathermanous in such different degrees. The rays of the red end were transmitted perfectly, even when plates of glass 800 millim. thick were used, or of rock-crystal 150 millim. thick. Through a thickness of 800 millim. of water, which absorbed a considerable portion of the light, 75 per cent of the heat-rays were transmitted.—Coloured media, as red glass, tincture of archil, certain green glasses, solutions of sulphate or bichromate of copper in ammonia, which only transmitted one colour, were also exclusively traversed by the heat-rays corresponding to these colours.—In the same way the light- and heat-rays proceeded together in media which transmitted two bands of colour, as sesquichloride of chromium, which transmitted red and green, and violet glass, which transmitted red and violet: finally, also, in blue glass of cobalt, whose spectrum exhibits several alternations of bright and dark bands.

(1) Compt. Rend. XXXI, 14; Instit. 1850. 218.

Transmis-
sibility of
the rays of
heat.

Masson and Jamin farther proved, by photometric and thermometric measurements, that in all these cases proportionate parts of the light- and heat-rays were transmitted. They consider that they have proved that the rays of both kinds, for equal refrangibility also have the same length of waves and the same velocity of propagation. They found that the deviations of the planes of polarisation of the light- and heat-rays were the same for both in passing through quartz and solutions of sugar; that the effect of thin plates, which caused a difference of path in the ordinary and extraordinary rays of $\frac{1}{4}$, $\frac{1}{2}$ or 1 wave-length, was the same for both kinds of rays. The above-named investigators therefore consider that they may lay down the general law, that whatever action takes place in light- and heat-rays of equal refrangibility, the numerical ratio of the intensities of the two kinds of rays before and after this action is the same, and that therefore the same cause may be assumed for the two kinds of rays.

We have not yet considered the critical remarks on those parts of Melloni's(1) latest work on radiant heat, which belong to the subject here treated of, and which Masson and Jamin have laid down as an introduction to their paper. Melloni(2) answers to these remarks, that it is very unjustly, and only from an erroneous conception of his work, that the conclusion is drawn that he either denies the identity of light- and heat-rays, or has not clearly laid it down. That he has already shown in his critique on the researches of Seebeck and Wünsch, that the maximum heat does not fall in different positions according to the material of the prism, but always at the red end of the spectrum, and that when the source of heat employed is not sufficiently small, that effect is only rendered apparent by the absorption of the dark heat-rays, which Masson and Jamin had altogether excluded from the discussion. That since, however, the greatest intensity of light, as is known, is in the yellow, it is necessary to call in a physiological cause to aid the explanation of this difference. This cause Melloni finds in the constitution of the retina, which, best adapted for the reception of luminous vibrations in the middle of the spectrum, exhibits a gradual decrease of susceptibility towards the end of the spectrum, just as the nerve of hearing does not recognise a sudden jump between audible and inaudible vibrations.—That proceeding from this, it may be conceived and proved by experiment, that the proportionality between the light- and heat-rays, as maintained by Masson and Jamin, by no means always holds good. That rays which have previously passed through water or alum have their illuminating power altered by coloured glasses in a totally different ratio from their heating power. That a glass, for instance,

(1) Comp. p. 45.

(2) Compt. Rend. XXXI, 470.

which only transmits red and orange, gives a pencil of rays of tolerably feeble illuminating power, but hot; that a glass which transmits yellow, green, &c., gives a pencil of rays having exactly opposite properties.

Reflection
and re-
fraction of
heat-rays.

Reflection and Refraction of Heat-rays.—Provostaye and Desains(1), assuming Fresnel's formulæ for the intensity of light reflected at a surface, have calculated the intensity of the reflected and refracted light for a plate with parallel surfaces, or for a pile of such plates, both for the case when the vibrations take place in and when they take place perpendicularly to the plane of incidence. It is indeed proved by Jamin's researches(2), that, accurately taken, Fresnel's formulæ correspond to no case in nature; and that instead of them the expressions given by Cauchy for metallic reflection must be applied in general to every reflection; but that for bodies whose coefficient of refraction is nearly equal to that of glass, Fresnel's and Cauchy's formulæ give, with the exception of a very narrow range in the neighbourhood of principal incidence, exactly equal values, and the results of Provostaye and Desains are consequently applicable in all these cases. The two investigators have farther also given formulæ for the quantity of polarized light which the reflected and also the refracted rays contain, and have shown experimentally that the reflection and refraction of the rays of heat follow exactly the same laws.—Put $\frac{\sin^2(i-r)}{\sin^2(i+r)} = R$ and $\frac{\tan^2(i-r)}{\tan^2(i+r)} = R'$, then the intensities are as follows:

Vibrations perpendicular to plane of incidence.	Vibrations in the plane of incidence.
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> $\underbrace{\hspace{1.5cm}}$ reflected ray. </div> <div style="text-align: center;"> $\underbrace{\hspace{1.5cm}}$ refracted ray. </div> </div>	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> $\underbrace{\hspace{1.5cm}}$ reflected ray. </div> <div style="text-align: center;"> $\underbrace{\hspace{1.5cm}}$ refracted ray. </div> </div>

For one reflecting surface:

$$R \qquad 1-R \qquad R' \qquad 1-R'$$

For two reflecting surfaces or a plate:

$$\frac{2R}{1+R} \qquad \frac{1-R}{1+R} \qquad \frac{2R'}{1+R'} \qquad \frac{1-R'}{1+R'}$$

For n parallel reflecting surfaces:

$$A = \frac{nR}{1+(n-1)R} \quad B = \frac{1-R}{1+(n-1)R} \quad A' = \frac{nR'}{1+(n-1)R'} \quad B' = \frac{1-R'}{1+(n-1)R'}$$

To confirm experimentally the applicability of these formulæ to the heat-rays, Provostaye and Desains employed extremely thin and clear glass plates of good polish, and only such heat-rays as had previously passed through a considerable thickness of glass. With

(1) Ann. Ch. Phys. [3] XXX, 159; Compt. Rend. XXXI, 19; Inst. 1850, 217.

(2) Annual Report, 1847-8, I, 132; for 1849, III, 71.

Reflection
and refraction
of
heat-rays.

these precautions, the loss from dispersion and absorption was extremely small. In order to render it still less sensible, the intensity of the reflected or refracted ray was not referred to the intensity of the incident ray as unity, but to the sum of those two rays. The coefficient of refraction of the glass, was 1.49. The agreement between observation and calculation was as near as possible, as the following results, among others, show.

1. Heat-rays which vibrate perpendicularly to the plane of incidence :

Number of plates.	Angle of incidence.	Intensity of transmitted heat.	
		observed.	calculated.
1	30°	0.706.	0.705
2	20°	0.370	0.374
3	40°	0.586	0.583
4	30°	0.396	0.371

2. Heat-rays vibrating in the plane of incidence :

1	15°	0.802	0.806
2	15°	0.676	0.675
3	15°	0.581	0.581

3. Natural unpolarized heat :

1	0°	0.92	0.92
2	0°	0.855	0.857
3	0°	0.80	0.80
4	0°	0.73	0.75

In the case where natural light or natural heat is employed, the intensity when n plates are used is :

For the reflected ray.

$$\frac{1}{2} (A + A')$$

For the transmitted ray.

$$\frac{1}{2} (B + B')$$

and the quantity of polarized light contained in the two rays .

$$\frac{1}{2} (A - A') = \frac{\frac{1}{2} n(R - R')}{[1 + (n-1)R] [1 + (n-1)R']}$$

$$\frac{1}{2} (B' - B) = \frac{\frac{1}{2} n(R - R')}{[1 + (n-1)R] [1 + (n-1)R']}$$

and consequently the ratio of the polarized to the unpolarized light is :

$$P = \frac{A - A'}{A + A'}$$

$$P' = \frac{B' - B}{B + B'}$$

If p is the quantity of polarized heat contained in the reflected ray, n the quantity of natural heat, then $P = \frac{p}{p+n}$, and if the principal section of a piece of calc-spar is placed first parallel and then

perpendicular to the plane of reflection, the transmitted ray contains in the one case the quantity of heat $k \left(p + \frac{n}{2} \right)$, in the other case $k \frac{n}{2}$, and the difference of the deviations of the thermometric column divided by their sum gives the value of P . The comparison of calculation and observation gave for $P = \frac{p}{p+n}$.

Reflection
and refraction
of
heat-rays.

Angle of incidence.	Observed value.	Calculated value.
10°	0.393	0.396
15°	0.574	0.587
20°	0.75	0.76

Provostaye and Desains found farther, the following laws, the analytical proof of which may be examined in the memoir itself(1):

1. When a single plate is used, the value of P' increases from direct incidence till the angle of incidence is 90° , and at this limit $= \frac{\lambda^2 - 1}{\lambda^2 + 1}$, where λ is the coefficient of refraction. Also this limiting value remains the same for any number of plates.

2. When several plates are used, P' reaches a maximum, which is more nearly equal to unity the more plates the ray passes through, while, at the same time, the angle of incidence at which this maximum occurs, continually approximates to the angle of polarization.

Provostaye and Desains have moreover generalized the formulæ they have obtained, so as to be applicable to parallel plates of different substances.

Jamin(2) has proved, as is known, that the intensity with which rays of light of different refrangibility are reflected at metal surfaces, for some metals, as steel and zinc, increases with the refrangibility; for others, which in consequence of this show an inclination to yellow and red colouring, as for instance, brass, copper, speculum metal, is less for the more refrangible rays. Provostaye and Desains(3) have now found that the same metals have exactly the same properties for the rays of heat of different refrangibility coming from the sun. The above-named physicists farther found that heat-rays which had proceeded from a lamp with a double draught of air, and were polarized, were reflected in greater quantity as the angle of incidence increased when the vibrations were

(1) Ann. Ch. Phys. [3] XXX, 173-5.

(2) Annual Report for 1847-8, I, 133.

(3) Ann. Ch. Phys. [3] XXX, 276; Arch. Ph. Nat. XV, 223; Compt. Rend. XXXI, 512; Inst. 1850, 322.

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perpendicular to, the plane of incidence, while exactly the reverse took place for heat vibrating in the plane of incidence.

Incidence.	Speculum metal.	Steel.	Platinum.	Tip.	Zinc.	Silver.	Brass.
Vibrations perpendicular to plane of Incidence :							
30°	0.71	0.69	0.687	0.69	0.685	—	0.875
50°	0.77	0.77	0.77	—	—	—	0.88
76°	0.89	0.90	0.865	0.888	0.835	0.98	0.895

Vibrations in the plane of Incidence :

30°	0.68	0.62	0.67	0.634	0.675	—	0.81
50°	0.64	0.55	0.634	0.62	0.655	—	0.79
76°	0.44	0.55	0.45	0.495	0.555	0.859	0.72

The reflection of the natural heat, which contains the sum of the two foregoing components, is, therefore, nearly the same for all angles of incidence between 30° and 76°.—Moreover, the reflection is the stronger the lower the source of heat is from which the rays proceed, as comparative experiments with solar heat, heat of the lamp with the double draught of air, the heat of a spirit-lamp, and a platinum plate heated to 400° proved.

Provostaye and Desains conclude, therefore, that the sources of lower temperature emit heat-waves of greater length, as is shown by Draper(1) to be the case likewise in the development of light. The results obtained by Provostaye and Desains with reference to the transmissibility of the heat from various sources of different intensity through water, agree with his opinion, since Melloni has shown that the transmissibility decreases with the refrangibility. Through a thickness of five centimetres of water, which was enclosed between two plates of glass, there passed out of every 100 rays, for

Solar heat, which had previously passed through 25 centimetres of water	92
Solar heat	58
Heat of an Argand lamp, which had passed through a glass lens and a thickness of 10 centimetres of water	51
Heat of the charcoal points in the galvanic circuit	23.5
Heat of chalk, in a flame of ether fed with oxygen	20
Dark solar heat, beyond the red	14
Heat of a Locatelli's lamp	10
Heat of a salted spirit-lamp	2.5
Dark solar heat, at a still greater distance from the red	0

Rotation of the Plane of Polarization by Fluids.—The same investigators have proved(2) that the plane of polarization of the heat-rays, which according to the researches of Biot and Melloni(3) is made

(1) Annual Report for 1847-8, I, 123.

(2) Ann. Ch. Phys. [3] XXX, 267; Pogg. Ann. LXXXII, 114; Arch. Ph. Nat. XIV, 370; XV, 227; Compt. Rend. XXXI, 53, 621; Instit. 1850, 228, 346.

(3) Compt. Rend. II.

to rotate by quartz, and, according to Provostaye and Desains' own investigations(1) by heavy glass under the influence of the electric current, also suffers a deviation from oil of turpentine and a solution of sugar; and that exactly the same laws hold for this as for the corresponding phenomena of light. The rotation of the plane of polarization is inversely proportional to the square of the wave-length (where it is presupposed that the same lengths of waves belong to the heat-rays as to the light-rays of the same part of the spectrum); it is directly proportional to the length of the column of fluid, and the quantity, by weight, of the active substance contained in a solution. —A solution of 31 parts of camphor in 69 parts of oil of turpentine, which, according to Biot, causes all the coloured rays of the spectrum to rotate nearly equally, has the same property with reference to the heat-rays.—Provostaye and Desains had in their experiments employed a fine solar spectrum in which Fraunhofer's lines could be distinguished, and separated from this small and therefore tolerably homogeneous coloured pencils, which they made to pass through a polarizing and an analysing Nicol's prism. The absolute magnitude of the deviation could not be accurately determined in the direct manner, on account of the small sensitiveness of the thermoscopic apparatus. Provostaye and Desains, therefore, measured the deviation of the needle of the galvanometer for two positions of the analysing Nicol's prism perpendicular to one another. The sum of the two is, according to Malus's law, equal to the greatest deviation, and if the deviation in any other position of the Nicol's prism is divided by it, we obtain the square of the cosine of the angle which the plane of polarization of the Nicol makes with the plane of polarization of the heat-ray after its deviation.—The following deviations, among others, were thus obtained through a column of oil of turpentine :

Rotation
of the
plane of
polariza-
tion by
fluids.

Length of the column.	Rotation of the plane of polarization	
	of the green ray.	of the red ray
0.15 ^m	— 58° 54'	— 32° 33'
	— 59° 13'	
0.10	— 39° 22'	— 20° 25'
	— 40° 12'	
	— 40° 0'	
0.05	— 20° 0'	— 10° 26'

Kinetics.—Electro-Magnetism as a Motive Power.—R. Hunt(2) in an interesting paper read before the Society of Arts, in London, has

(1) Annual Report for 1849, III, 33.

(2) Phil. Mag. [3] XXXVI, 550; Athenæum, No. 1179, 588; Sil. Am. J. [2] .X, 282.

Kine-
tics.
Electro-
magnet-
ism as a
motive
power.

shown the unprofitableness of the application of electro-magnetism as a motive power.—The mechanical effects of equal weights of coal and zinc—the former applied in a Cornish steam-engine, the latter in a Grove's battery—are, according to Hunt, as 143:80; the costs as 1:24. Hence the economic effects are as 42:1. But even this ratio cannot be reached, for the magnetic power generated, loses considerably by the distance, and besides is weakened by the motion of the anchor and by inductive currents.

Petrie(1) has also brought forward considerations on the mechanical effect of the electric current in comparison with that of heat, and expects more favourable results than Hunt from a proper application of the former.—Petrie finds that if the electro-motive power of Daniell's element is put = 60, an element which has an electro-motive power = 100, develops a power of 302.5 English foot-pounds for a consumption of one grain of zinc per minute: farther, that in the Daniell's circuit a horse power is produced by the consumption of 1.56 lbs. in the hour, but that in the best electro-magnetic machines, as yet, a horse power is only attained by a consumption of 50 or 60 lbs. of zinc, consequently, only $\frac{1}{37}$ of the theoretical power. In the best Cornish steam-engines $\frac{1}{17}$, and in locomotives usually only $\frac{1}{100}$ of the power generated is available. Petrie believes, concluding from the nature of these forces, that the employment of electricity with the application of the proper means, will some day furnish more favourable results than the employment of heat; he gives, however, no hint as to how this object is to be attained.

On the other hand, Page(2) has made experiments on a very extended scale, on the construction of electro-magnetic machines, and expects, as a result of farther efforts, that the economic effect will become equal to that of the more expensive steam-engines.

Statics.—Proofs of the law of the parallelogram of forces have been given by Crelle(3) (a dynamical proof) and Möbius(4). Crelle(5) has given a new theory of the lateral pressure of earth against resisting walls.

Tenacity of Metals at Different Temperatures.—Baudrimont(6) has investigated the tenacity of some metals at 0°, 100° and 200°, producing the temperatures by melting ice, by a water-bath and by an oil-bath. He obtained the following values:

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- (1) Instit. 1850, 414; Edinb. new Philos. Journ. L, 66.
 - (2) Sill. Am. J. [2] X, 343; Phil. Mag. [4] I, 161.
 - (3) Berl. Acad. Ber. 1850, 145.
 - (4) Sächs. Acad. Ber. 1850, I, 10.
 - (5) Berl. Acad. Ber. 1850, 71; Instit. 1850, 255.
 - (6) Ann. Ch. Phys. [3] XXX, 304; Compt. Rend. XXXI, 115, (in abstr.); Instit. 1850, 241; Phil. Mag. [3] XXXVII, 308; Pogg. Ann. LXXXII, 156; Ann. Ch. Pharm. LXXXVI, 123.

Metal.	Section in square millimetres.	Tenacity for 1 ^{mm} section in grammes.		
		0°	100°	200°
Gold . . .	0·13364	19051	15766	13094
		18400	15224	12878
Platinum ^a .	0·13202	23026	20421	18118
		22925	19284	17277
Copper . . .	0·18095	25338	22050	19839
		25100	21873	18245
Silver . . .	0·12456	28620	24526	18705
		28324	23260	18577
Palladium .	0·12409	36983	32871	29212
		36481	32484	27077
Iron . . .	0·02405	209813	201039	213305
		205405	191725	210270

Tenacity of metals at different temperatures.

The first of the two values which are given for each metal and for each temperature, is the greatest which was obtained in the repetitions of the same experiment; the second value is the mean of all the experiments. It is seen that the tenacity in general diminishes as the temperature increases; the change of tenacity is proportionally greater in silver, and less in copper, gold, platinum and palladium, than that of the temperature. Iron alone forms an exception, inasmuch as it had smaller tenacity at 100° than at 0°, but greater at 200° than at 100°.

Wertheim(1) has communicated some historical notices with reference to Baudrimont's researches.

Equilibrium and Motion of Solid Elastic Bodies.—Maxwell(2), in a paper on the elasticity of solid bodies, draws attention in the first place to the fact that the hypotheses on which other mathematicians, especially Navier, have based the equations of equilibrium of elastic bodies are too restricted, because they comprise only one constant which changes with the nature of the substance. He remarks that since solid bodies endeavour to preserve not only their volume but also their figure, since the same substance may appear in different states of solidity, it is unavoidably necessary to introduce two constants into the fundamental equations. Maxwell bases his equations on the two following conditions, in which it is supposed that three pressures act on the element of mass of an elastic body along three rectangular axes.

1. The sum of the three pressures is proportional to the sum of the three compressions which they produce.
2. The difference between two pressures is proportional to the difference between the corresponding compressions.

(1) Ann. Ch. Phys. [3] XXX, 507; Baudrimont's Reply (1851) Ann. Ch. Phys. [3] XXXI, 508.

(2) Edinb. Trans. XX, Part I, 87.

Equilibrium and motion of solid elastic bodies.

Maxwell remarks that the equations obtained from these conditions only differ from Navier's in this, that an invariable ratio between linear and cubic compression or expansion is not presupposed in them, and that those equations agree accurately with those which Stokes has deduced from his considerations of motion in fluids.

After Maxwell has subjected the works of a great number of mathematicians and physicists on elasticity to a short critical comparison, he remarks that experimental determinations have hitherto been wanting concerning the relations between the double refraction which is produced by pressure in glass and other elastic bodies, and the pressures themselves. That he has ground for assuming that in homogeneous single refracting bodies, the axes of elasticity of the ether lie in the same directions as the principal axes of pressure, and that the difference of the pressures along two axes is proportional to the difference of the velocities of the two rays, polarized perpendicularly to one another, which are propagated in the direction of the third axis.

Maxwell repeatedly makes use of the phenomena which bodies with two parallel bounding surfaces exhibit in polarized light when they are subjected to external pressures or tensions, to control the results of the analytical development.—Unfortunately the limits of of this Report do not allow of communicating the process of these developments; we must be content with citing the results and the consequences drawn from them.

If $\frac{\delta\alpha}{\alpha}, \frac{\delta\beta}{\beta}, \frac{\delta\gamma}{\gamma}$ indicate the compressions along three principal axes α, β, γ ; P_1, P_2, P_3 the applied pressures, the expression of the conditions stated above gives :

$$P_1 + P_2 + P_3 = 3\mu \left(\frac{\delta\alpha}{\alpha} + \frac{\delta\beta}{\beta} + \frac{\delta\gamma}{\gamma} \right); \quad P_1 - P_2 = m \left(\frac{\delta\alpha}{\alpha} - \frac{\delta\beta}{\beta} \right)$$

$$P_2 - P_3 = m \left(\frac{\delta\beta}{\beta} - \frac{\delta\gamma}{\gamma} \right), \quad P_3 - P_1 = m \left(\frac{\delta\gamma}{\gamma} - \frac{\delta\alpha}{\alpha} \right)$$

If $\delta x, \delta y, \delta z$ are the displacements in the directions of the co-ordinate axes, and X, Y, Z , the internal attractions along these axes, we have the equations :

$$\left(\mu + \frac{1}{6}m \right) \frac{d}{dx} \left(\frac{d\delta x}{dx} + \frac{d\delta y}{dy} + \frac{d\delta z}{dz} \right) + \frac{m}{2} \left(\frac{d^2\delta x}{dx^2} + \frac{d^2\delta y}{dy^2} + \frac{d^2\delta z}{dz^2} \right) + \rho X = 0$$

$$\left(\mu + \frac{1}{6}m \right) \frac{d}{dy} \left(\frac{d\delta x}{dx} + \frac{d\delta y}{dy} + \frac{d\delta z}{dz} \right) + \frac{m}{2} \left(\frac{d^2\delta x}{dx^2} + \frac{d^2\delta y}{dy^2} + \frac{d^2\delta z}{dz^2} \right) + \rho Y = 0$$

$$\left(\mu + \frac{1}{6}m \right) \frac{d}{dz} \left(\frac{d\delta x}{dx} + \frac{d\delta y}{dy} + \frac{d\delta z}{dz} \right) + \frac{m}{2} \left(\frac{d^2\delta x}{dx^2} + \frac{d^2\delta y}{dy^2} + \frac{d^2\delta z}{dz^2} \right) + \rho Z = 0$$

These equations, as Maxwell remarks, coincide with Cauchy's(1), if k is put for m and K for $\mu - \frac{m}{2}$, and with Stokes,(2), if $A = 3\mu$ and $B = \frac{m}{2}$.—Maxwell now passes to the consideration of the following single cases :

Equilibrium and motion of solid elastic bodies.

1. A hollow cylinder, whose external surface is fixed, while the internal is turned by a couple through a small angle. As regards the optical effect, Maxwell finds in this case that the difference of path of the two rays polarized perpendicularly to one another is inversely proportional to the square of the distance from the axis of the cylinder, and that the angle of the directions of polarization is bisected by the radius drawn to the point in question. The system of rings in polarized light on this account has exactly opposite properties to that in uniaxal crystals, because the arrangement of colour increases towards the centre, and the rings here become narrower and narrower. Maxwell obtained the phenomenon by means of a jelly of isinglass, which was poured hot between two concentric cylinders. When he let it cool, while the turning power acted, the solid substance exhibited still the same optical phenomenon.
2. The same cylinder as No. 1, which is turned through a certain angle, not over the whole internal surface, but at one point.
3. A hollow cylinder, which is only subjected to normal pressure.
4. The compression of a hollow sphere, which is subjected to internal and external pressures, as is the case in experiments on the compressibility of fluids. Maxwell compares his results with those which Lamé(3) had deduced from the experimental researches of Regnault.
5. The equilibrium of a uniformly-bent prismatic rod.
6. The equilibrium of a circular elastic plate which, fixed at its circumference, is bent to a concave surface by a pressure uniformly spread over the whole surface (for instance, by the pumping out of the air from a cylindrical vessel behind the plate, as Nasmyth proposed, to exhibit a concave mirror; Maxwell remarks that such a reflector would serve as an optical aneroid barometer.)
7. Conditions of torsion of a cylinder, which consists of a bundle of thin wires.
8. Calculation of the internal pressure, which is called into play in its own mass by the centrifugal force of a rotating cylinder.
9. State of equilibrium of a tube, which is surrounded externally by a medium of constant temperature, while a fluid of different temperature flows through the tube.
10. State of equilibrium of a cylinder which is suddenly and greatly heated over its external surface.
11. State of a hollow sphere which conducts heat from the inside to the outside, or the converse, as for

(1) Exerc. d'Anal. III, 180 (1828).

(2) Cambridge Philos. Trans. VIII, Part 3.

(3) Annual Report for 1847-8, I, 102.

Equilibrium and motion of solid elastic bodies.

instance, the bulb of a thermometer. 12. Equilibrium of a rod, which is bent together into a ring. 13. Two cylinders, whose axes are perpendicular to an unlimited elastic plate, and which are turned through a certain angle in the same direction. Comparison of the results with the isochromatic curves which the elastic plate shows in polarized light.

Finally, Maxwell draws attention to the fact that the state of constraint which takes place in unannealed glass, cannot be deduced from the equations of equilibrium of elastic bodies, that for this we rather require in addition the knowledge of the laws of cooling and solidification; but that from the form of the isochromatic curves in polarized light, we can draw conclusions as to the position of the principal axes of tension or pressure.

Cox(1) is of opinion that the assumptions, from which we set out in calculating the bending of an elastic rod, namely:—1. that the longitudinal extension or compression is proportional to the force; 2. that the extension and compression produced by equal forces are equal,—are inaccurate. He expresses the force which produces an extension e in a rod by a series $\alpha e + \beta e^2 + \beta' e^3$, and then obtains for the equation of the elastic curve a far more complicated form than Poisson found under those more simple hypotheses. Experimental proofs are not added to the paper from which we extract these notices.

Baudrimont(2) has made experiments on the motion of elastic bodies with several axes of elasticity perpendicular or even oblique to one another, and remarks that these experiments have enabled him to determine the law of dependence of the elasticity on the direction. He has found a method of preparing plates which, as regards the conditions of elasticity, may replace the plates of crystal, which can only be had on a small scale.—The Eulerian formulæ are, according to Baudrimont, only applicable to the vibrations of thin rods, which are fixed at one end, whether these are cut out of homogeneous bodies, or bodies with several axes.

Rankine(3) distinguishes three kinds of elasticity of solid bodies: 1. The *longitudinal elasticity*, that is, the resistance which arises from the extension or compression in the direction of the acting force; 2. the *lateral elasticity*, which is brought into play, perpendicularly to the direction of the acting force; and 3. the *transversal elasticity*, that is, the resistance which solid bodies oppose to twisting or change of form in general. He finds that the following laws hold independently of any hypothesis as to the constitution of matter: 1. In every homogeneous elastic substance there are three directions per-

(1) Phil. Mag. [3] XXXVII, 151.

(2) Compt. Rend. XXXI, 886.

(3) Inst. 1850, 317.

pendicular to one another, along one of which a force must act in order to produce a resultant reaction in its own direction. These three directions are called axes of elasticity, and to these as co-ordinate axes it is simplest to refer all pressures and tensions, and molecular displacements. The elasticity of a body is expressed with reference to these axes by twelve coefficients; three coefficients of longitudinal, six of lateral, and three of transversal elasticity. 2. The coefficient of transversal elasticity is the same for all directions lying in one plane. 3. In each of the above co-ordinate planes, the coefficient of transversal elasticity, or stiffness, is equal to the fourth part of the sum of the coefficients of longitudinal elasticity diminished by a fourth part of the sum of the two coefficients of lateral elasticity.—Besides these general laws, Rankine develops others, based on especial hypotheses, as, for instance, his hypothesis of molecular vortices(1), which may be found in the extract cited from his paper.

W. Wertheim(2) has given a very beautiful summary of the principal results of his investigations concerning the general laws of equilibrium and motion of solid and fluid bodies, as well as the conclusions thence following. Our previous Reports(3) contain communications concerning the whole of the results contained in this summary.

Compressibility of Fluids.—Grassi(4) has again(5) studied the compressibility of fluids with the apparatus(6) constructed by Regnault. The formulæ were corrected according to Wertheim's result(7) as to the relation between cubic and linear compression. The results obtained were: 1. that the compressibility of distilled water free of air decreases as the temperature rises; 2. that in all other fluids investigated the compressibility increases with the temperature; 3. that the compression of water for one atmosphere is independent of the pressure, as also in salt-solutions and mixtures of sulphuric acid and water, on the contrary it increases with the pressure for ether, alcohol, pyroxylic spirit and chloroform; 4. that in salt-solutions the compression is greater the more diluted they are.—Here follow also some numerical results; the velocity of sound is calculated from the formula:

$$v = \sqrt{\frac{9.8088 \times 0.76 \times 13.596}{\rho \times d}}$$

(1) Comp. p. 35.

(2) Wien. Acad. Ber. 1850, June 19th.

(3) Annual Report for 1847-8, I, 96, 99, 106; Annual Report for 1849, III, 38, 39, 43.

(4) Instit. 1850, 265; more in detail (1851) Ann. Ch. Phys. [3] XXXI, 427.

(5) For his former experiments we refer to the Annual Report for 1847-8, I.

(6) Annual Report for 1847-8, I, 102.

(7) Ibid. 96.

Compressibility of fluids.

Fluid.	Temperature.	Compression for 1 atmosphere.	Pressure from which the value is found.	Velocity of sound in metres!
Mercury . . .	—	0.0000295	—	—
Water . . .	0°	0.0000503	—	1419.8
" . . .	10.8	0.0000480	—	1452.9
" . . .	25.0	0.0000456	—	1493.5
" . . .	53.3	0.0000441	—	1526.1
Ether . . .	0	0.000112	3.408 atm.	—
" . . .	0	0.000131	7.820	—
" . . .	13.8	0.000153	8.362 "	—
Alcohol . . .	7.3	0.0000828	2.302 "	—
" . . .	13.1	0.0000991	8.97 "	—
Pyroxylic spirit . . .	13.4	0.0000913	—	—
Chloroform . . .	8.5	0.0000625	—	—
" . . .	12.5	0.0000764	9.2 atm.	—

Fluid.	Temperature.	Density.	Compressibility for 1 atmosphere.	Velocity of sound.
Solution of chloride of calcium No. 1	17.5	1.218	0.0000306	1650.1
" " " No. 2	15.8	1.417	" 206	1864.2
" " " No. 2	41.25	1.339	" 229	1775.5
Solution of chloride of sodium No. 1	18.5	1.1226	" 321	1676.6
" " " No. 2	18.1	1.2024	" 257	1812.4
" " " No. 2	39.6	1.188	" 263	1802.8
Solution of iodide of potassium . .	15.5	1.694	" 260	1615.6
Solution of nitrate of soda . . .	18.1	1.2026	" 295	—
Solution of carbonate of soda . . .	16.6	1.182	" 297	—
Sea-water . . .	17.5	1.0264	" 436	—
SO ₃ + 2 HO . . .	13.6	—	" 242	—
SO ₃ + 3 HO . . .	14.6	—	" 250	—
SO ₃ + 4 HO . . .	16.5	—	" 271	—
SO ₃ + 5 HO . . .	14.7	—	" 279	—
SO ₃ + 6 HO . . .	14.2	—	" 283	—
SO ₃ + 10 HO . . .	14.6	—	" 315	—

Mariotte's Law.—E. B. Hunt(1) remarks, that Mariotte's law must necessarily hold in every homogeneous mass, since whatever attractive or repulsive forces may be acting, these must depend on the mass, and increase in intensity proportionally with it quite independently of the law by which these forces increase or decrease with the distance.—Conversely that the inapplicability of Mariotte's law must indicate the absence of perfect homogeneity. Since then that law is not strictly applicable to gases, and not at all to liquids and solid bodies, it follows therefore, that all these bodies have amolecular structure, since heterogeneity cannot be conceived without the hypothesis of molecules.

(1) Sill. Am. J. [2] IX, 412; Phil. Mag. [3] XXXVII, 76.

Barometric Formula.—Babinet(1), to avoid the use of logarithms, proposes, instead of Laplace's barometric formula

Barometric formula

$$h = 18393^m (\log B - \log b) \left\{ 1 + \frac{2(T+t)}{1000} \right\}$$

to make use of the following

$$h = 16000^m \frac{B - b}{B + b} \left\{ 1 + \frac{2(T+t)}{1000} \right\}$$

If an approximation is not sufficient, or the differences of height exceed 1000 metres, an intermediate station must be made use of, if Babinet's formula is to be sufficient.

Influence of the Time of Day on the Barometric Measurement of Heights.—Bravais has(2) drawn attention to the fact that, as has already been previously remarked by Deluc, Ramond and Horner, the time of day exerts an influence on the measurements of heights by the barometer, so that a correction variable with the hour of the day has to be applied to the results. He assumes that the correction is proportional to the difference of heights, and endeavours to determine its value for the different hours of the day. In a table of corrections designed for the same purpose, deduced by Horner from observations, which Bravais also communicates, that proportionality is not assumed.

General Laws of Motion.—Dopkin(3) has published a memoir on the geometrical laws of the motion of an invariable system about a fixed point. Sylvester has(4) also communicated some remarks on the same subject.

Theory of the Motion of Fluids.—On the equation of continuity(5), so called by Challis, which he has put forward for the theory of the motion of fluids, a discussion has arisen, in which Tardy(6) expresses the opinion that that equation is neither necessary nor of any use, while Challis(7) endeavours to prove afresh its necessity.

Spouting of Water through Rectangular Openings.—Lesbros(8) has communicated to the French Academy results of experiments which he made in the years 1828—34, on the efflux of water through vertical rectangular openings of greater width. It is impos-

(1) Compt. Rend. XXX, 309; Instit. 1850, 89; Pogg. Ann. LXXX, 224.

(2) Compt. Rend. XXXI, 175; Instit. 1850, 250.

(3) Phil. Mag. [3] XXXVI, 427.

(4) Phil. Mag. [3] XXXVII, 440.

(5) Annual Report for 1849, III, 41.

(6) Phil. Mag. [3] XXXVI, 171.

(7) Ibid. 295.

(8) Compt. Rend. XXXI, 86; Instit. 1850, 243; a very favourable report was made to the Academy by Boncelet, Compt. Rend. XXXI, 733.

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sible for us here to cite individually the results of 1100 experiments on the efflux from openings limited above, and 206 experiments on that from openings free above, and we communicate only some more general laws.—For openings of the first kind Lesbros found: 1. The coefficients of efflux depend only on the smallest distance of the opposite edges, and remain the same, however the other dimension may be altered, provided that it does not exceed twenty times the first dimension, which condition is always satisfied in practice. 2. The coefficient remains the same whether the length of the opening is directed horizontally or vertically, if the pressure at the upper edge is not changed.—Farther, Lesbros found for openings of the second kind: 1. The sides of the cistern exercise an influence on the quantity of water flowing out, if the breadth of the cistern is not at least ten times as great as the channel of efflux; while according to other observers, this influence is said either not to exist at all, or to cease when the breadth of the cistern is four times as great as that of the channel. 2. The efflux is greater the nearer the bottom of the cistern is to the bottom of the current. 3. The obstacles which several observers have applied to the openings, in order to lessen the velocity of the stream, alter the laws of efflux.—Lesbros thinks, that with proper attention to the circumstances here enumerated, the very discordant results of different observers may be brought into harmony.

Flow of Water in Canals and in Tubes.—Saint-Venant(1) remarks that Prony's equation for the motion of water in open canals and in tubes, namely:

$$RJ = aU + bU^2$$

where J is the fall in one metre, U the mean velocity, R the quotient of the section divided by its moistened perimeter, a and b constants to be calculated by experiment, is too complicated for the analytical solution of problems in hydraulics, and on that account is by many engineers exchanged for the equation $RJ = cU^2$. He is of opinion that the advantage of a monomial equation may be obtained without departing so far from the truth, as is the case in the last assumption, by putting $RJ = cU^m$, and deducing immediately from experiments a fractional value for m (between 1 and 2). That this assumption, from which $\log(RJ) = \log c + m \log U$ follows, is admissible, is clear from this, that if with the observed values of $\log U$ as abscissæ, and of $\log(RJ)$ as ordinates, a curve is laid down, the deviations from a straight line are within the limits of the errors of observation. By three methods of approximation Saint-Venant calculates from ninety-three experiments the value of m , and arrives conclusively at the formulæ for motion

in canals: $RJ = 0.00040102 U^{2\frac{1}{2}}$, $U = 60.16 (RJ)^{\frac{1}{1\frac{1}{2}}}$

in tubes: $\frac{DJ}{4} = 0.0002956 U^{\frac{7}{2}}$, $U = 114.49 \left(\frac{DJ}{4} \right)^{\frac{2}{7}}$

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in which D is the diameter, and J the loss of pressure in one metre due to friction.—Saint-Venant applies the first formula to the calculation of the peculiar motion of water at points where it is dammed up by weirs, and extends these calculations in a second memoir(1) also to the case when the breadth of the canal is very great compared with its depth.

As to a memoir of Lefort(2) on the motion of water in tubes, more detailed communications are wanting.

Motion of Fluids in Elastic Tubes.—Volkman(3) has communicated an extract from his work on the motion of the blood, from which we select those results which without special physiological reference express the relation of the pressure on the side to the velocity of a fluid circulating in elastic tubes. Poiseuille had, by inserting a manometer tube, found the pressure to be equally great in all points of the circuit. It is, however, known that the lateral pressure of a fluid streaming out through a stiff tube, decreases constantly towards the mouth, being at each point proportional to the frictional resistance which has to be overcome up to the efflux. Volkman first made experiments with stiff combinations of tubes, in which narrower and broader tubes, as well as repeatedly bent tubes alternated, and found also in this case the law just cited to be confirmed. He then passed to experiments with elastic tubes. A reservoir 15 decim. deep had an orifice at the lower end of the side to which a tube was attached with a stopcock. This was opened and shut by means of a powerful pendulum, so that the water was forced by gushes (like the blood from the heart) into an elastic tube of goat's gut, 4 metres long and 45^{mm} in circumference. By means of a manometer tube, the regularly alternating maxima and minima of pressure were observed, and thence the mean pressure p deduced, the velocity v was found from the quantity flowing out. The result was that the observations could be very well represented by the equation $p = Av^2 + Bv$.

By means of Ludwig's kymographion, which exhibits graphically the oscillations in a manometer applied to an artery, and by that means allows the mean pressure to be measured with great accuracy, Volkman found the pressure in the same artery is less the farther from the heart the manometer is applied; consequently, in this case

(1) Compt. Rend. XXXI, 581.

(2) Instit. 1850, 87.

(3) Ann. Ch. Phys. [3] XXX, 286; Ann. Ch. Pharm. LXXVI, 135 (in abstr.)

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also the above law was verified.—Volkman measured the velocity of the blood flowing in the arteries by means of a glass tube bent into the form of a siphon, to which a stopcock with a double bore was applied, so that in one position the blood proceeded the direct way, and then by a quick revolution of the cock, took its course unimpeded through the glass tube, at the same time pushing before it the fluid with which the latter was filled. It resulted that the velocity only slightly decreased from the wider to the narrower parts of the vessels, and was first suddenly considerably retarded in the vicinity of the capillaries.—The formula given by Gerstner for the relation between pressure and velocity: $p = \frac{4l}{d} \left\{ a \cdot \frac{v^2}{2g} + b \frac{v}{\sqrt{d}} \right\}$ in which l is the length, d the diameter of the tube, g double the space fallen through in the first second under the action of gravity, a and b two empirical constants, was applicable throughout to the blood flowing through the arteries, as for instance the following measurements made on a dog prove:

Observed velocity.	Pressure.	
	observed.	calculated.
280.0mm	2106mm	2106mm
259.0	1957	2003
186.7	1728	1691
88.4	756	707
48.0	405	405

From the first and last observations a was found = 23.618 and $b = 1.5423$.

Velocity of Propagation of Waves in Water.—Robertson (1) has considered analytically the primary advancing wave or positive advancing wave (so-called by Scott Russell) which is formed when an impulse is exerted on the quiet surface of a fluid, and the body which displaced the particles of the fluid then retains the place thus taken, so that the molecules of water which advanced in a curved ascending or descending path, while the wave moved through their position, do not return again. Robertson finds the vertical component of oscillation of a particle of water expressed by the equation

$$t = \sqrt{\frac{a+k}{3g}} \frac{1}{\cos \frac{x}{k}}, \text{ where } a \text{ is the depth of the disturbed or vibrating}$$

fluid, $2k$ the height of the wave, x the elevation of a particle above the smooth surface, and t the time.—The velocity of propagation of the wave is, according to Robertson, expressed by

$$v = \sqrt{\frac{a+k}{a}} (a+2k) g, \text{ while Scott Russell's empirical formula,}$$

(1) Phil. Mag. [3] XXXVII, 512.

derived from his numerous experiments, was $v = \sqrt{(a + 2k)g}$.—From the tables which Robertson has given for the comparison of Russell's experiments with the results of his formula, it follows that the latter gives the velocity of propagation constantly somewhat too great.—Robertson communicates the result of an experiment of his own, which was made to determine whether the viscosity of the fluid produced that difference. The velocities of waves of equal height in linseed-oil and water, were in the ratio of 2:2.13. At the same time this result seems to deserve no great confidence. It is to be regretted that the rich experimental determinations of the brothers Weber(1) on the motion of the waves were not taken into consideration.

Velocity of propagation of waves in water.

On the Motion of Streams of Water.—A considerable number of physical, and very large atmospherical processes depend partly on the influence which a stream of liquid or gaseous fluid exercises when it rushes into a larger space filled with the same fluid, and which generally consists in its drawing a part of the surrounding fluid into the moving stream. Venturi(2) and Feilitzsch(3) have already rendered these facts evident by experiments with flowing water; lately, however, Magnus(4) has studied the process and illustrate it by a series of experiments. He proved, first, that it is possible to totally prevent the efflux of water out of a vessel with a tolerably wide orifice, by causing a jet of water, whose diameter is far less than that of the orifice of the vessel, to rush against the water in this orifice with sufficient velocity. The experiment succeeds as well when the orifice is in the side, as when it is made at the bottom, and the thinner jet rises vertically. Since, however, by the water streaming in, the depth of water producing pressure in the vessel is gradually increased, an instant arrives at last when the efflux can no longer be prevented by the thinner jet of water. In order that the phenomenon may last, it is necessary to maintain the water in the vessel at a constant level by another place of efflux. Magnus had inserted into the orifice of the vessel a wide glass tube, in the axis of which the thinner jet of water was conducted against the fluid. In this case, at the place where the jet came in contact with the fluid, a strong froth was seen, and bubbles of air were carried on with the current into the vessel. Magnus sees in this the same phenomenon which is observed daily on the pouring of water into a glass, whereby likewise bubbles of air are carried by the incident stream down to the bottom of the vessel. The opinion that this takes place in consequence of

(1) Wellenlehre. Leipzig, 1825.

(2) Venturi, Recherches Expérimentales sur le Principe de la Communication Latérale du Mouvement dans les Fluides.

(3) Pogg. Ann. LXIII, 216.

(4) Pogg. Ann. LXXX, 1; Phil. Mag. [4] I, 1.

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the adhesion or friction of the water on the air, or through the air being carried forward in the discontinuous jet, Magnus endeavours to contradict by the proof that a short jet, which has not yet reached the maximum of contraction, and is quite smooth on the surface can likewise carry down with it bubbles of air far below the surface. That such a jet forms at first only a circular indentation, which continues unaltered for a quiet surface; but on the least shaking or disturbance, if only a drop is allowed to fall on the surface in another place, or if the jet carries a little bubble of air with it, the indentation closes suddenly on the jet with a hissing sound, and greater bubbles are carried downwards. (See pp. 6 and 7).—Magnus endeavours to give a still farther confirmation to this opinion by the relation which he established between his own experiments and those of Savart on the junction of two equal jets of water. If two jets of water of equal section and with equal velocity impinge on one another, in such a manner as to have a common tangent, the water at the point of concurrence flows away sideways in a transparent plane sheet. If the jets have unequal velocities or unequal sections, or if both these are the case, the plane sheet changes into a curved surface, whose vertex, according to the experiments of Savart, always is nearer to the orifice from which the wider jet flowed. If, however, the ratio of the diameters of the two jets is greater than 1.41, the thinner jet enters altogether into the vessel with the wider orifice. Instead now of one curved surface, on account of other irregular influences, a quantity of small closed surfaces are formed, which produce the appearance of foam.—When Magnus caused the jet to flow against a hollow hemisphere of metal, the water gliding off formed a completely closed case which was traversed by the jet without farther disturbance.—When the wider tube was directed horizontally; and a vertical tube was set up at right angles to it, somewhat farther from the vessel than the place where the jet impinged on the water, the water (poured in through this tube) was likewise carried forward and towards the vessel by the jet. If the vertical tube was connected by an air-tight joint with a flask filled with air, out of which a second tube, bent like a siphon, opened, the lower end of the longer leg of which was immersed in mercury, and if the tube which conducted the thin jet was likewise inserted air-tight in the opening of the wider tube, the mercury rose: the point where the jet impinged amidst foam on the fluid approached the vertical tube, and when it arrived thither the fluid mounted upwards.

In order to obtain a still closer insight into the nature of the matter, Magnus made two series of quantitative determinations. In the first series he endeavoured to determine the force of the perpendicular impulse of the jet of water, which penetrated into a greater quantity of water in a horizontal direction, against a smooth vertical disc at different distances from the orifice of efflux. He employed

openings in a thin side or efflux tubes of various lengths, but always a jet of about 3^{mm} diameter, as well as a pressure of two or three metres, plates of from 100^{mm} to 200^{mm} diameter which were fixed at one end of the beam of a balance, and measured the pressure by balancing weights for distances of the plate from the orifice of efflux, varying from 50^{mm} to 250^{mm}. The result was, as well when the disc was vertical and the stream was directed horizontally, as when the stream impinged perpendicularly downwards on the horizontal plate, that the force of the impulse increased up to about 150^{mm} distance from the orifice.

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A second series of experiments was to show in what way the jet and the surrounding fluid mingle. For this purpose Magnus caused pure water to flow into a solution of common salt, and held at the point of the stream whose composition was to be investigated, a glass tube with a finely-opened point, which was slightly bent so that the fluid flowed out at the other end, (which projected a little above the level), exactly of the composition which it had at the pointed end, and thus could be collected separately and subjected to chemical analysis. —When the point was held close before the orifice of efflux, then pure water alone entered without a trace of salt. But even at a distance of 10^{mm} a mixture of the two fluids was obtained, even in the axis of the jet, and the amount of salt increased very considerably when the point was directed 2^{mm} or 3^{mm} out of the centre of the jet.

Magnus passes now to the explanation of the phenomenon. He remarks that the jet on its entrance into the unconfined fluid spreads itself out continually. In order, then, that equal quantities of fluid may pass in equal times through each section, the velocity must diminish accurately in the same ratio as the section itself increases. From this would follow a diminution in the *vis viva* of the jet, for which there is no cause, disregarding the inconsiderable influence of friction. If, however, the transverse slices of the jet as they become broader and broader retain their velocity, a greater quantity passes in the same time through sections which are farther from the orifice of efflux than through sections in the vicinity of the opening. This increase of the quantity in motion is only supplied by taking in part of the surrounding fluid. There also arises at the same time a considerable decrease of the lateral pressure of the fluid, as has been also theoretically developed by Bernoulli and Poisson, and actually proved in streams of gas by the rarefaction produced. Magnus now shows how the above-described phenomena may be individually explained from the views communicated. With reference amongst other things to the increase of the impinging force of the jet of water on the flat plate with the increase of the distance from the orifice, Magnus remarks that the pressure of the fluid streaming sideways from the plate is less than the statical resistance on the other side, and that this difference becomes more considerable the greater

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the velocity of the jet is, consequently, is greatest in the vicinity of the opening. He shows that this difference of pressure, however, in each case, has to be subtracted from the impinging force of the jet, and that the remainder therefore is more considerable at a greater distance from the orifice.

By the fact that the surrounding fluid takes part in the motion of the jet, the motion towards one another of two parallel discs, one of which allows a jet of air or water to pass through its centre may, according to Magnus, be explained; moreover, on this depend the whirling motions which occur when a jet flows with sufficient velocity into a fluid of the same kind, the peculiar motions of ascending smoke, the spiral propagation of storms. In a separate appendix, Magnus has sought to reduce the action of the blasting machine, called *trombe hydraulique*, to the preceding principle, and has described an apparatus which, he says, will illustrate the process, and prove the correctness of the explanation.

Motion of Gases through Capillary Tubes.—The experiments which Graham long since made on the velocity with which different gases mingle (diffusion), and also on the velocity with which they flow through an opening in a thin partition into an empty space (effusion), conducted him to the same law of the dependence of the velocity on the density. The times of passage of equal volumes were found under all circumstances to be proportional to the square roots of the densities of the gases.—In a later inquiry, carried through with the known perseverance of this observer, Graham (1) has investigated whether the efflux of gases through longer or shorter capillary tubes (transfusion or transpiration) follows the same or other simple laws. It appeared that for short tubes the efflux still follows approximately the law of effusion, but that the deviations, which are produced by the resistance of the sides of the tubes, conceal that law more and more the longer the tubes are which are used; that when a certain limit of length of tube is exceeded, constant ratios again appear between the quantities flowing out or the velocities of efflux of the different gases, which, however, have nothing in common any longer with the simple law of effusion cited above.—Graham proposed to himself the problems, to determine: 1. how the resistance depends on the dimensions of the capillary tube when this already gives normal transpiration; 2. the velocities of transpiration of different gases and vapours; 3. the influence which changes in the density and tension of the gases exercise on the transpiration; 4. the influence of temperature.

Graham expresses the results of this inquiry in the following manner: 1. The velocities with which different gases pass through capillary tubes are to one another in a determinate invariable ratio, and are

(1) Phil Trans for 1849, II, 349; Phil Mag [3] XXXV, 541 (in abstr.); Ann Ch. Pharm. LXXVI, 138; Ann. Ch. Phys. [3] XXVIII, 457; Instit. 1850, 410.

therefore dependent on an especial property of these gases (transpirability). The constancy of the ratios has been proved for capillary tubes in which the resistance varied from 1 to 1000 times. The following ratios are especially worthy of note: The velocity for hydrogen is double as great as for nitrogen and carbonic oxide. The velocities for nitrogen and oxygen are inversely proportional to the densities of these gases. The velocity of nitric oxide is equal to that of nitrogen and carbonic oxide. The velocities of carbonic acid and nitrous oxide are equal, and compared with oxygen directly proportional to the densities.—The velocity of light carbonated hydrogen is 0·8 of that of hydrogen; that of chlorine is 1·5 that of oxygen; that of the vapour of bromine and sulphuric acid is equal to that of oxygen; that of the vapour of ether is equal to that of hydrogen.—The velocities of olefiant gas, of ammonia and of cyanogen, appear to be nearly equal, and twice as great as that of oxygen.—The compounds of methyl appear to have a less velocity than the corresponding compounds of ethyl. Both appear, however, to bear a constant ratio to one another.

Motion of
gases
through
capillary
tubes.

2. The resistance of a capillary tube of equal width throughout to the passage of gas is proportional to its length.

3. The velocity of passage of equal volumes of air, of the same temperature, but different tension, is directly proportional to the density.

4. Heat diminishes the velocity of passage in the same manner as this would happen by a decrease of tension.

5. Capillary tubes of great resistance are requisite in order to prove the law with reference to densities; and to observe that of temperatures, the greatest resistances possible are necessary.

6. The velocity of efflux is directly proportional to the density whether the increase of this latter depends on compression, cooling, or the accession of an element, as for instance, the combination of oxygen with carbonic oxide, so as to form carbonic acid.

An inspection of the results communicated under 1. shows, without doubt, that in the passage of different gases through long capillary tubes, the laws of motion (independent of the chemical nature) which hold, for instance, in the efflux through openings in a thin diaphragm, are almost entirely concealed or superseded by the action of other forces.—Graham remarks, that the action appears to him to be independent of the containing material, since the transpiration remained the same in tubes of glass, brass or gypsum. The experiments communicated, however, were all made with capillary tubes of glass.

E. W. Blake(1) has communicated a memoir on the motion of gases which expand freely, this, like one detailed in a previous Report(2), is remarkable for paradoxical results. The changes of

(1) Sill. Am. J. [2] IX, 334.

(2) Annual Report for 1847 and 1848, I, 112.

Apparatus
and
machines.

density are said not to be gradual, but to proceed by jumps to a half, a quarter, &c., of the original density; similarly, the velocity of the particles is said to increase, &c.

Apparatus and Machines.—Improvements in the air-pump have been indicated by Varley(1). Mignot de Baran(2) has constructed a double air-pump with one tube, and laid it before the French Academy, remarking at the same time, however, that similar arrangements had been already invented previously, for instance, by Smeaton in 1752.

Potter(3) communicates the description of an aerometrical balance (air manometer), which is to measure local states of density, which cannot be found with the barometer, thermometer, and psychrometer. A similar instrument for the same purpose was invented and described by Franz von Gerstner long since, 1791(4).

Lovering(5) has subjected the action of the aneroid barometer in comparison with the mercurial barometer to an extended investigation, in order to learn the degree of dependence to be placed on the former. —First, the performance of the instruments was compared by rarefying and condensing the air under the bell of an air-pump. The index of the aneroid barometer had a range which corresponded to one of the mercurial barometer from 20 to 31 inches; it changed with the rarefaction of the air more quickly than the mercurial barometer, with a variable difference of the two instruments which fluctuated from 0.1 to 0.5 inches. Only, in the vicinity of the boundary of the range the differences decreased again, changed their sign, and the aneroid barometer ceased from that point to be useful. The comparison of the two instruments for the usual atmospheric fluctuations, gave the indication of the aneroid barometer always somewhat too low, and this was also not quite independent of the temperature. The correction for 1° amounted to 0.0021 inches.—Lovering farther was convinced that, when the air under the bell of the air-pump was rarefied, and then brought back to its previous density, the index of the aneroid barometer did not return accurately to its previous position, but fell short of it by as much as 0.1 inch of barometric pressure. —The above-named physicist hence considers that the aneroid barometer may serve the seaman, for the purpose of detecting great disturbances in the state of the atmosphere which precede storms; but that for neither meteorological observations, nor for measurements of heights, does that instrument offer a sufficient cer-

(1) Sill. Am. J. [2] X, 284.

(2) *Compt. Rend.* XXX, 409; *Instit.* 1850, 114.

(3) *Phil. Mag.* [3] XXXVII, 81.

(4) Gerstner, *Handbuch der Mechanik*, Prag. 1832, Th. II, 117; comp. Gehler's *Phys. Wörterb.*, enlarged edition, VI, 1206.

(5) Sill. Am. J. [2] IX, 249; *Ann. Ch. Pharm.* LXVI, 133 (in abstract)

tainty.—A description and representation of the aneroid barometer, from a work published by Dent, has been communicated in the same journal(1). Apparatus and machines.

Schrön(2) has published in a form better adapted for practical chemists the table calculated by Steinheil and Seidel(3) for *The Reduction of Weighings to a Vacuum*.

Breguet(4) describes an instrument for the purpose of measuring the velocity and the time of stopping of railway trains.

Caligny(5) describes an alteration which he has applied to the aspiration apparatus invented by him, in which he replaced the piston by a play of fluid columns. With farther communications on the same subject(6), Caligny connects the description of a new phenomenon(7) of suction which, however, is not easily intelligible without the requisite diagrams.

L. D. Girard(8) communicates the description of a new arrangement applicable to water-wheels and turbines (*barrage hydropneumatique*).

J. Phillips(9) has brought forward new proofs of the applicability of his anemometer, which, as has been already mentioned in last year's Report(10), determines the velocity of the wind from the vaporization produced by it in water, and the cooling thereby effected. Phillips adds, that the cooling power of the wind is proportional to the square root of its velocity, if the proper corrections are applied on account of the moisture present in the air.

Coffin(11) describes an instrument which serves to measure the changes and duration of the wind.

With reference to the anemometer by Legeler, see p. 43.

Dynamics of the Earth.—A paper has appeared by Smythies(12), on the theory of attraction.

Equilibrium of a Fluid Mass at Rest under the Influence of External Attraction.—Roche(13) has found that a fluid mass which is at rest, and is only subject to the attraction of its own particles, and that of a distant point, according to the Newtonian law, has two figures of equilibrium. Both are prolate ellipsoids of revolution, whose axes of revolution are directed to the attracting point. The elongation

(1) Sill. Am. J. [2] VIII, 286.

(2) Arch. Pharm. [2] LXI, 257.

(3) Münchener gelehrte Anzeigen, 1848, No. 37, &c.

(4) Instit. 1850, 27.

(5) Instit. 1850, 85.

(6) Instit. 1850, 372.

(7) Instit. 1850, 373, 396; 1851, 13.

(8) Compt. Rend. XXXI, 708.

(9) Report of the British Association, note and abstract, XIX, 28; Inst. 1860, 20.

(10) Annual Report for 1849, III, 46.

(11) Proceedings of the American Association, II, 386.

(12) Essay on the Theory of Attraction; comp. Phil. Mag. [3] XXXVII, 301 and 340.

(13) Compt. Rend. XXXI, 515; Instit. 1850, 321.

Equilibrium of a fluid mass at rest under the influence of external attraction.

depends on the quotient of the mass of the attracting body by the density of the fluid and the cube of the distance of the two masses. When this ratio approaches zero, one ellipsoid passes into a sphere, the other disappears. If the ratio increases, the ellipsoids approach one another, and at last coincide in one, whose axis of revolution is about 25 times as great as the diameter of its equator. For still greater values of this ratio, a state of equilibrium no longer exists. For instance, for a fluid of the density of air under the influence of the attraction of the sun at the distance of Mercury, none of the above-cited states of equilibrium would any longer be possible.

The same investigator has taken up more generally the problem mentioned in last year's Report(1), of determining the figure of equilibrium of a fluid mass, which rotates and is subject to the attraction of a distant point lying in the plane of its equator(2), by not assuming, as in the first solution, that the velocity of rotation, and the angular velocity relatively to the attracting point are equal, as appears to be certainly the case with the satellites. Laplace has already remarked, that if the two velocities were originally not equal, and the mass of the satellite were considered to be fluid, the equality would be gradually produced by the attracting influence of the central body. Roche has treated this problem afresh.

Faye(3) has communicated interesting considerations on the internal heat of the earth, and on the possibility that the solid crust of the earth opposes sufficient resistance to the tidal motions of the interior fluid mass.

Tides.—Brouwin(4) has continued his mathematical researches into the theory of tides, which were mentioned in last year's Report(5).

Whewell(6) gives a synopsis of the results of tidal observations at 120 coast stations of England and the neighbouring shores.

Waves of the Sea.—Stevenson(7) has constructed an instrument for the purpose of measuring the mean force of the waves in different seas, which consists of a disc against which the waves strike, and a spiral pen which registers the force of the impulse. Stevenson found the force of the waves to be 1.5 tons on the English square foot in the Baltic, and 3 tons in the Atlantic Ocean.

Baudrimont(8) considers that he has found, with an instrument constructed by him, which enables the density of the air to be mea-

(1) Annual Report for 1849, III, 48.

(2) Instit. 1850, 117.

(3) Instit. 1850, 329.

(4) Phil. Mag. [3] XXXVI, 190 and 343.

(5) Annual Report for 1849, III, 48.

(6) Phil. Mag. [3] XXXVI, 549; Phil. Trans. for 1850, I, 227; Instit. 1850, 292.

(7) Instit. 1850, 398.

(8) Instit. 1850, 395.

sured by the weighing of a light body of great volume (*arérodensimètre*), that the density of the air besides depending on the temperature, the pressure, and the moisture, depends also on the influence of light, and on the electric state. He has not yet determined the quantitative value of this last influence.

Acoustics.
Nodal lines of rods vibrating transversely.

Acoustics.—Nodal Lines of Rods vibrating transversely.—Lissajous(1) has investigated experimentally the position of the nodal lines in rods vibrating transversely in the six following cases: 1. when the rod is free at both ends; 2. when it is fixed at both ends; 3. when it is free at one end and fixed at the other; 4. when it is fixed at one end and pressed against at the other; 5. when it is fixed at one end and pressed against at the other; 6. when it is pressed against at both ends; which had been previously performed for the first case only by Strehlke(2). He has, by a skilful treatment of the Eulerian formulæ, proved the agreement of observation and calculation, and shown that there is a determinate law of the arrangement of the nodal lines, which holds for all harmonic notes, independently of the substance and the dimensions of the rod.

We will give the mode of treatment for the first case only at length, and for the five others communicate the results as briefly as possible. The observations for this case Lissajous made on rods of steel and brass from 0.5 to 1.5 metres long, which were laid perfectly clean on edges of cork-wood, so that these latter always fell in the vicinity of a nodal line, or accurately coincided with one; they were strewn with dry sand, and then scraped with a violin-bow. The nodal lines were indicated so sharply that their position could be accurately found to $\frac{1}{5}$ of a millimetre.

If a is the length of the rod, S the distance of a nodal line from the end, and $\frac{S}{a} = u$, then, according to Euler, u is given by the equation:

$$e^{\omega u} \mp e^{\omega(1-u)} + (1 \pm e^{\omega}) \sin \omega u + (1 \mp e^{\omega}) \cos \omega u = 0 \quad (1).$$

where ω is determined by the equation

$$\frac{1}{\cos \omega} = \frac{1}{2} (e^{\omega} + e^{-\omega}), \quad (2).$$

ω may also be expressed by the equation

$$\omega = \frac{a}{\sqrt[4]{bc^3k}}$$

(1) Ann. Ch. Phys. [3] XXX, 385.

(2) Pogg. Ann. XXVII, 505; XXVIII, 223.

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lines of
rods vi-
brating
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versely.

where a is the length, c the thickness of the rod, b a constant depending on the material, and k the length of the simple pendulum which vibrates in the same time as the rod.—The roots of equation (2) are approximately :

$$\frac{3\pi}{2}, \frac{5\pi}{2}, \frac{7\pi}{2} \dots \frac{(2m+1)\pi}{2},$$

and the upper or lower signs must be used in (1) according as m is even or odd. Lissajous shows that equation (1) may be replaced by

$$\sin \omega u - \cos \omega u = e^{-\omega u} + e^{-\omega(1-u)}. \quad (3)$$

without sensible inaccuracy, and the roots which lie between the limits $\omega u = 0$ and $\omega u = \frac{(2m+1)\pi}{2}$ may be represented by the abscissæ of the points of intersection of the curves :

$$\left. \begin{aligned} y &= \sin \omega u - \cos \omega u \\ y' &= e^{-\omega u} - e^{-\omega(1-u)} \end{aligned} \right\} \text{ or } \left. \begin{aligned} y &= \sin \omega u - \cos \omega u \\ y' &= e^{-\omega u} + e^{-\omega(1-u)} \end{aligned} \right\}$$

according as m is even or odd. The construction shows that the curve of y' , at least when the number of nodes is greater than four, reckoned from the end, only differs sensibly from the axis of abscissæ for a short distance beyond the first node. Consequently, the nodes, with the exception of the last, in the vicinity of the ends, may be found from the equation :

$$\sin \omega u - \cos \omega u = 0.$$

The difference of two adjacent roots, as is easily seen from this equation, $= \pi$, consequently the distance D of two adjacent nodal lines :

$$S_{p+1} - S_p = \frac{\pi a}{\omega} = \frac{2a}{2m+1}$$

and since the number of nodal lines $n = m+1$, the distance $D = \frac{2a}{2n-1}$. The experiments on a brass rod 0.5 metres long, for from the fourth to the thirteenth harmonic note, agreed perfectly with the results just deduced.—For the last node but one, we have $\omega u = \frac{5\pi}{4}$, consequently :

$$u_2 = \frac{5\pi}{4} \div \frac{(2m+1)\pi}{2} = \frac{5}{4n-2} \text{ and } S_2 = \frac{5a}{4n-2}.$$

This expression also Lissajous has found confirmed in the experiments cited.—The distance of the last node from the end may be calculated from the equation :

$$\sin \omega u - \cos \omega u = e^{-\omega u}$$

since in this case the term $e^{-\omega(1-u)}$ in the equation (3) is insensible. Since $\omega u = \frac{\pi}{4} + \delta$, by substituting this value, we find by approximation $\delta = 14^\circ 28'$, and hence $S_1 = \frac{0.6608 a}{2n-1}$, which also agrees very accurately with observation.—Lissajous remarks also, that according to this, the ratio $\frac{S_1}{S_2} = 0.26432$ is a constant ratio, independent both of the special peculiarity of the rod and of the pitch of the harmonic note; farther, that $\frac{S_2 - S_1}{D} = 0.9196$, consequently that with the same generality the distance of the two nodal lines which lie next the end of the rod amounts to only 0.92 of the nodal distances lying farther on. Experiment gave as a mean the ratio $\frac{10}{11} = 0.91$.

The experiments for the second principal case, in which the two ends of the rod are to be fixed, Lissajous succeeded best in, by soldering the two ends of the rod into masses of brass of 1.5 kilogr. weight, and lining these latter underneath with cloth, so that the vibrations could not be communicated to the support in a sensible degree. The nodal lines assumed the same positions as in the rod free at both ends, with the single difference that the first and last nodal lines were removed to the ends of the rod. The expressions calculated for S_2 , S_{n-1} and D of the first case, hold therefore here also.—Euler gives for this case the formulæ :

$$\frac{1}{\cos \omega} = \frac{1}{2} (e^{\omega} + e^{-\omega}) \quad \text{and}$$

$$e^{\omega u} \mp e^{\omega(1-u)} - (1 \pm e^{\omega}) \sin \omega u - (1 \pm e^{\omega}) \cos \omega u = 0$$

and the latter is reduced as in the first case to

$$\sin \omega u - \cos \omega u = -e^{-\omega u} \pm e^{-(1-u)\omega}$$

where the upper sign is to be taken when m is even, and the lower when m is odd. The roots

$$0, \left(\frac{5\pi}{4} + \delta_2\right), \left(\frac{9\pi}{4} - \delta_3\right), \dots, \left(\omega - \frac{9\pi}{4} + \delta_3\right), \left(\omega - \frac{5\pi}{4} - \delta_2\right),$$

differ little from

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versely.

Nodal
lines of
rods vi-
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versely.

$$0, \frac{5\pi}{4}, \frac{9\pi}{4}, \dots, \omega - \frac{9\pi}{4}, \omega - \frac{5\pi}{4}, \omega.$$

In the third case the rod was soldered at one end into a mass of brass, and at some one other point propped up by a cork edge, which was fixed on a heavy mass of lead. The nodal lines were situated as in the two previous cases, except that the free end was as in the first case, the fixed end as in the second case. The formulæ

$$S_1 = \frac{0.6608 a}{2n-1}, S_2 = a - S_{r-1} = \frac{5a}{4n-2} \text{ and } D = \frac{2a}{2n-1},$$

agreed with observation. The Eulerian equations for this case, according to the reduction given by Lissajous are:

$$\frac{1}{\cos \omega} = -\frac{1}{2} (e^{\omega} + e^{-\omega}), \text{ and}$$

$$\sin \omega u - \cos \omega u = e^{-\omega u} + e^{-(1-u)\omega}.$$

The two following cases also can be reduced to the two first, if we consider the end which is pressed against as coinciding with one of the inner nodal lines. The rod thus vibrates like the half of a rod twice as long, whose two ends are free or fixed, and which contains $2n-1$ nodal lines.

In the fourth case we have accordingly

$$S_1 = \frac{2 \times 0.6608 a}{4n-3}, S_2 = \frac{5a}{4n-1} \text{ and } D = \frac{4a}{4n-3}.$$

The experiments, which in this case it is difficult to perform, agreed very well with these formulæ. The Eulerian formulæ are in this case:

$$\tan \omega = \frac{e^{\omega} - e^{-\omega}}{e^{\omega} + e^{-\omega}}, \text{ from which } \omega = \frac{(4m+1)\pi}{4}, \text{ and}$$

$$e^{\omega u} - e^{\omega(2-u)} + (1 + e^{2\omega}) \sin \omega u + (1 - e^{2\omega}) \cos \omega u = 0.$$

Lissajous proves that equation (II) of the first case may be deduced from this by transformation.

In the fifth case the experiments are more easily performed. They agreed well with the formulæ:

$$S_2 = \frac{5a}{4n-3}, \text{ and } D = \frac{4a}{4n-3}.$$

Euler gives $\tan \omega = \frac{e^{\omega} - e^{-\omega}}{e^{\omega} + e^{-\omega}}$, and

$$e^{\omega u} - e^{\omega(2-u)} - (1 + e^{2\omega}) \sin \omega u - (1 - e^{2\omega}) \cos \omega u = 0.$$

The sixth case, finally, has already been completely treated by Euler, the nodal lines have throughout equal distances, as Chladni also has found experimentally.

The relations which Lissajous finds between the pitch of the harmonic note and the number of nodal lines are very beautiful. If the ends which are fixed or pressed against are counted as nodes, it is found that for

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2, 3, 4, 5, 6, n nodes,

the number of vibrations are proportional to the squares of

3, 5, 7, 9, 11, $2n-1$ (A)

in the first three cases, of

5, 9, 13, 17, 21, $4n-3$ (B)

in the fourth and fifth cases, and of

1, 2, 3, 4, 5, $n-1$ (C)

in the sixth case. If the number of vibrations for two nodes in the last case is taken as a unit, the ratio of the number of vibrations for the cases under *A*, *B* and *C* for n nodal lines is :

$$\frac{(2n-1)^2}{4} \quad \frac{(4n-3)^2}{16} \quad (n-1)^2,$$

and that of the distances D of two nodal lines lying in the interior :

$$\frac{2a}{2n-1} \quad \frac{4a}{4n-3} \quad \frac{a}{n-1}.$$

The number of vibrations can, therefore, be expressed in every case by $\frac{a^2}{D^2}$; it is under all circumstances inversely proportional to the square of the length of one of the vibrating portions in the interior.

Lissajous remarks that the formulæ for D , S_1 and S_2 also give accurate results for four and three nodal lines, and that

$S_1 = \frac{0.6608a}{2n-1}$ also is applicable for two nodal lines. Finally, he

draws attention to the fact that the method by which he has found so simple a relation between pitch and length of nodal divisions, and which is dependent on this, that the lower notes in the harmonic series, in which the influence of the boundaries of the vibrating body extends to the centre, are excluded from consideration, is certainly also applicable with advantage in other parts of acoustics, and will there also conduct to simpler relations. He states that the pitch of the note should be compared with the dimensions of that division to which the influence of the boundaries does not extend, and that this is particularly requisite in the vibrations of plates.

Vibrations of a Circular Plate.—Kirchhoff(1), as has been already

Vibrations
of a circular
plate.

briefly mentioned in last year's Report(1), has completed the calculation of the vibrations of an elastic circular plate on a new basis, after he had perceived that the hypotheses from which Miss Germain and Poisson had started, were not satisfactory. Kirchhoff has calculated the numerical results, so far as a deviation was to be expected, both for the older and newer constant of elasticity of Wertheim(2) ($\theta = \frac{1}{2}$ and $\theta = 1$). The differences, however, are too small to allow of deciding with certainty in favour of the one constant or the other by comparison with the results of observation. If the plate forms m diametral and μ concentric nodal lines, the ratio of the intervals of the corresponding notes is :

$\theta = \frac{1}{2}$						
μ	$m=0$	$m=1$	$m=2$	$m=3$	$m=4$	$m=5$
0			1.0000	2.3124	4.0185	6.1982
1	1.6131	3.7032	6.4033	9.6445	13.3937	17.6304
2	6.9559	10.8383	15.3052	20.3219		
3	15.9031					
$\theta = 1$						
μ	$m=0$	$m=1$	$m=2$	$m=3$		
0			1.0000	2.3274		
1	1.7284	3.9072	6.7111	10.0762		
2	7.3344	11.4003				

The notes which Chladni found experimentally in a circular plate agree very well with these results. The vibration-numbers of the higher notes approximate, as may be seen, and as Chladni also remarked, more and more to the ratio of the squares of the numbers ($m + 2\mu$).

The following formulæ serve for calculating the absolute pitch S of a plate where the radius = l , the semi-thickness = ϵ , the coefficient of elasticity = q , the density of the material = ρ :

$$\text{For the hypothesis } \theta = \frac{1}{2}; S = \frac{\epsilon}{l^2} \sqrt{\frac{q}{\rho}} 1.04604.$$

$$\text{For the hypothesis } \theta = 1; S = \frac{\epsilon}{l^2} \sqrt{\frac{q}{\rho}} 1.02357.$$

The radii of the nodal lines as given by theory, have been compared with the measurements of Strehlke on four glass and two metal discs from 5 to 7 Paris inches diameter, and 0.7 to 1.1 lines thick, and found to agree very well.

Strehlke(3) remarks that the measurement on plate-glass had proved most perfectly the circular form of the nodal lines; while for circular discs of copper and brass, with equally accurately parallel planes, the nodal lines were elliptic, and consequently showed un-

(1) Annual Report for 1849, III, 43.

(2) Annual Report for 1847-8, I, 96.

(3) Berl. Acad. Ber. 1850, 360; Instit. 1851, 125.

equal elasticity in different directions. The radii of the nodal circles, which were situated nearest to the edge of the disc, agreed to $\frac{1}{10}$ of their length with the calculated values, but are almost always less than these. The radii of the smaller enclosed circles agree almost accurately with the theoretical values on the hypothesis of $\theta = \frac{1}{2}$.

Vibrations
of a circular
plate.

The disturbance took place at the edge, and Strehlke considers on this account that for the external nodal circles the hypothesis of indefinitely small vibrations no longer holds. For a central mode of disturbance he imagines the outer circles would agree best.

Notes from the Heating of Glass Balls.—Sondhauss (1) has subjected the origin of the notes in the heating of glass balls, blown on tubes 2 or 3 millim. wide, which has already been studied by Pinaud (2) and Marx (3) to a new and more extended investigation. He was convinced that the air in the glass tube is the sonorous body; that with a suitable relation between the ball and tube the apparatus begins to sound at about 310° ; that the commencement of the sound is particularly facilitated by the place in which the ball and tube meet (the neck) being exposed to the action of the flame; farther, that the presence of vapours in the ball promotes, indeed, the commencement of sound in many cases, but is not absolutely unconditionally necessary to it, as Pinaud thought. Farther, it appeared that the figure of the receiver, melted on to the tube, may vary between tolerably wide limits without the pitch of the note being altered, if only the volume remains the same; and finally, Sondhauss found that the tube after being cooled, gave a note when blown on, which was a half of whole note lower than the note which was audible during the heating. He explains this deviation by the greater density of the completely cooled air, which previously, in the vicinity of the ball at least, was expanded by the heat, as well as by the partial covering of the upper opening of the tube, which cannot be avoided in blowing on it with the mouth. We may hence assume that the air in the apparatus which sounds by heating, vibrates according to the same laws as in an organ-pipe closed at one end.—The origin of the sound Sondhauss explains as follows:

When the heated air of the ball has come to equilibrium with the pressure of the atmosphere, there is a place in the neighbourhood of the neck where the heated air of the ball and the cooler air of the tube border on one another. This boundary fluctuates in continual motion up and down, because the equilibrium between the hot air in the ball and the external cold air is continually disturbed by the cooling; but again restored by the continued action of the flame, &c. When the column of air is once set in vibration, the heat of the ball

(1) Pogg. Ann. LXXIX, 1.

(2) Pogg. Ann. XLII, 610; Instit. 1836, 366.

(3) J. Pr. Chem. XXII, 129.

Notes
from the
heating of
glass
balls.

may even somewhat decrease without the sound immediately ceasing on that account.

As regards the dependence of the pitch of the note on the dimensions of the apparatus, Sondhauss first investigated the influence of the length of the tube. The vibration-numbers were nearly inversely proportional to the square roots of the lengths of the tubes. The ratio of the square roots of the lengths of tube, however, is throughout somewhat less than that of the vibration-numbers, and the deviation becomes more considerable for greater intervals. By the considerable shortening of the tube, which occurs for the higher notes, the portion of the column of air which is warmed by the influence of the ball, becomes a greater and greater portion of the whole vibrating column, hence an elevation of note must occur exceeding that corresponding to the lengths. Farther, the vibration-number is inversely proportional to the square root of the volume of the ball, and directly proportional to the square root of the section of the tube, so that if n is the vibration-number, S the section, L the length of the tube, V the volume of the ball, and C a constant :

$$n = C \sqrt{\frac{S}{V \cdot L}}$$

If V is expressed as a length of tube (L') of section S , then $n = \frac{C}{\sqrt{L \cdot L'}}$

and if the apparatus are similar when an invariable ratio exists between the volumes of the ball and tube, and therefore $L' = c^2 \cdot L$, then $n = \frac{C}{cL}$; that is, the vibration-numbers are inversely proportional to the homologous dimensions, as Savart had found for stopped pipes of similar figure.—The mean value of the constant C in the preceding formula, Sondhauss found to be = 104400.

In order to prove still more accurately that the law of vibration described, and the formula which expresses it, are applicable to stopped pipes which are blown in the usual manner, Sondhauss fixed glass tubes of various lengths and widths, on small cylindrical glass flasks, and altered the volumes of the flasks by pouring in water. The same laws were recognized also in this case, but Sondhauss found the constant $C' = 93410$, since, as was remarked above, the note produced by blowing with the mouth is always somewhat lower. The same constants might be used to calculate the notes which various other flasks of very different form and magnitude gave. Except that when the neck and the tube were very short and wide in proportion to the flask, greater deviations occurred.

Theory of Humming-Tops. Cubical Pipes.—Sondhauss(1) has, in

another memoir investigated the musical properties of the humming-top, and found them to agree with the laws of vibration of the cubical pipes. C. Marx(1) tried to explain the origin of the sound by the impulse which the air thrown out of the top by the centrifugal force exercised on the external surrounding air. Sondhauss placed the top on the centrifugal machine in an eccentric position; first, with the side opening turned outwards, then inwards. It sounded equally well in both cases; and it was impossible in the latter position that the air should be driven outwards by centrifugal force.

Theor.
humming-
tops.
Cubical
pipes.

The origin of the sound is properly explained by F. Savart as a blowing exactly similar to that of the pipes, only with this difference, that in the latter a current of air is driven against the edge of the open slit, while in the top, on the contrary, the edge is put in motion and driven against the air. Sondhauss's remarks on this, that a sharp edge is by no means requisite. Tops of wood, in which the edge was rounded off by the file, nevertheless sounded well.

In order to learn the laws of vibration of cubical pipes in general, Sondhauss employed a small cylindrical glass vessel, 80^{mm} high, and 60^{mm} wide, and cemented to it plates of sheet-tin, in which slight openings of arbitrary width could be cut. Through a tube beaten out wide in the front, a flat stream of air was conducted across the opening against one of its edges, and the pipe thus blown. The volume was altered at pleasure by pouring in water. The vibration-numbers were inversely proportional to the square root of the volume of the cubical pipe. At the same time, it was indifferent whether the vessel stood horizontally, or was inclined so that the water rose on one side of it. The form of the volume of air, therefore, which sounds is of no importance. When the vessel was nearly quite full, and consequently the volume was exceedingly small, the note did not quite reach the pitch which is given by the above law. Farther, the vibration-numbers are proportional to the fourth roots of the superficial content of the opening which is blown on. Yet the form of the opening is not quite without influence, for the note, *cæteris paribus*, is higher the greater the circumference of the opening. If s is the superficial content of the opening, V the volume

of the cubical pipe, the vibration-number is $n = \frac{C\sqrt[4]{s}}{\sqrt{V}}$. Sondhauss

found the mean value of the constant $C = 104800$. He has with this completed the calculation of the notes of a great number of humming-tops, of wood, brass and sheet-iron, in the form of spheres and double cones; also of a number of short pipes in the form of cubes, cylinders, cones, truncated cones and pyramids, and found them agree nearly with the results of experiment. He farther shows how his

(1) J. Pr. Chem. XXII, 133.

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formula embraces the two laws found by Savart, according to which, 1., the vibration-numbers for pipes of similar form are inversely proportional to their homologous linear dimensions; and 2. the vibration-numbers of parallelopipedal pipes of dissimilar forms are inversely proportional to the square roots of the side surfaces, which are perpendicular to the opening.

The result, that the note of a short pipe depends on the volume of the enclosed air, is contradicted by experiments of Liscovius(1), who states that the note of a flask-shaped pipe did not change, when he filled the greater part of it with rods of wood. Sondhauss sunk sticks of sealing-wax in the above-described cylindrical pipe of glass, and found that the note became higher as the volume diminished, and indeed in accordance with the formula given above.

With shorter pipes the strength of the blast has a much more considerable influence on the pitch of the note than in the usual organ pipes. Sondhauss thinks that for more feeble blasts the particles of air most distant from the opening do not take part in the vibrations at all, and therefore the resulting note is about a second higher. As regards the rest, the theoretical investigation (as for instance the opinion, that those parts of the wave which had to travel over a greater distance from the wind-slit to the corners and sides of the pipe, move with greater velocity in consequence of the mutual adhesion of the particles of air) is not quite intelligible.

With reference to the influence of several openings, Sondhauss found that the cubical pipe divided itself up in such a manner with nodal surfaces, that in all parts vibrations of equal duration were performed. When the openings are of equal size, we have accordingly to substitute $\frac{V}{2}$, $\frac{V}{3}$, &c., for V in the formula, to find the pitch of the

note. It is moreover indifferent how the openings are situated with respect to one another, and the divisions are by no means always congruent. If the openings in the cubical pipe, or the humming-top, are of unequal magnitudes, the spaces into which it is divided are also unequal, so that the smaller space belongs to the smaller opening, the vibration-number for each space, however, is calculated by

the formula $n = C \frac{\sqrt[4]{s}}{\sqrt{V}}$. To four unequal openings of the areas a^2 , b^2 , c^2 , d^2 , correspond for instance the divisions

$$A = \frac{a V}{N}, B = \frac{b V}{N}, C = \frac{c V}{N}, D = \frac{d V}{N},$$

where V is the volume of the whole pipe, and $N = a + b + c + d$.

Instrument with a Mathematically Accurate Tuning of the Intervals.—H. W. Poole(2) has communicated a memoir on the physico-

(1) Pogg. Ann. LX, 482.

(2) Sill. Am. [2] IX, 58, 199.

Instrument with a mathematically accurate tuning of the intervals.

mathematical foundation of harmony and correct tuning of instruments, and at the same time has announced that he has built an organ which, by means of a simple arrangement of pedals, enables one to play the keys from C to those indicated by five sharps (\sharp) and five flats (\flat), with perfect purity, consequently, without any temperament. Since this memoir, standing on the boundaries of the departments of music and acoustics, for the most part belongs rather to the former, we cannot here enter into a special analysis of it, and will only state that in this ingenious and excellent work, the physical basis of harmony is developed with a clearness which we have never before found.—The vibration ratio, $\frac{7}{4}$ is vindicated to the harmonic seventh, and the strange opinions which are told almost generally about the chord of the seventh, and farther about the character of different kinds of keys, are shown with a sharp criticism to be perfectly unfounded.—No competent judge will refuse to agree with the author, when he asserts that the uniform temperament has no foundation in the nature of music, but is only an expedient of necessity, which was seized on because of the practical difficulties of instrument building and of playing. We certainly cannot judge whether these difficulties are removed by the construction of the author, and only remark that Poole asserts that his organ has been played on for nine months with ease by all musicians and those not the best instructed, and that it seems as if we might have great confidence in the author of a work, like that mentioned above, to which we wish a very general circulation.

Apparatus and Instruments.—Traill(1) describes a Peruvian musical instrument which, cut out of stone and bored, contains eight pipes, arranged as in the Greek syrinx. Four of these pipes have, near the end where they are blown, a side opening, which in playing the instrument must be closed with the finger, for the pipe to sound. The performer has it, therefore, in his power to omit certain notes, without giving up the usual convenient manner of playing this instrument.

Cagniard-Latour(2) describes a little brass wind instrument, which he has had made to assist in his researches into the different qualities (*Klang*) of notes. In a farther communication, Cagniard-Latour(3) brings new proofs of an opinion already previously stated by him, that the vibration of the air in whistling with the mouth is produced by the friction of the emerging air on the lips.

Page(4) states that the motion of the Trevelyan instrument may be produced by the electric current, without the application of external

(1) Edinh. Trans. XX, Part I, 121.

(2) Instit. 1850, 84.

(3) Instit. 1850, 390.

(4) Sill. Ar.-J. [2] IX, 105; Arch. Nat. XIII, 313.

Optics. Sources of light. heat. The stand, therefore, like the vibrating bars, may consist of copper or brass; at best, of two rails laid parallel, of which one is connected with one pole of a battery, and the other with the other. The development of heat at the points of contact keeps up the motion, just, as in the usual manner of causing the instrument to sound.

Optics.—Sources of Light.—Masson(1) has convinced himself by his study of electric photometry, that bright lines of invariable position occur on the spectrum of the electric light; he has as yet distinguished four and applied them to measure indices of refraction.

Page(2) communicates a notice on the galvanic light, from which it does not clearly appear whether he endeavoured to prove that this light is partially polarized, or only that it can be polarized.

Recamier(3) believes that he has discovered that illuminated bodies are repelled, and dark bodies attracted by sources of light presented to them, just as similar magnetic poles repel, and opposite ones attract, one another. Quatrefages(4) has made known the results of his investigations concerning the luminosity of marine animals. Petrie(5) communicates considerations and observations on the phosphorescence of potassium.

Photometric Investigations.—Arago(6), now that the condition of his sight does not permit him to continue his investigations, has given the Academy an account of his many years of labour at photometry. The extended memoirs are not yet in our hands. From the brief abstracts which are as yet published, we can only enumerate the problems, of which Arago has undertaken the solution, and cite but little of what he has effected.

In order to be able to graduate a *polarimeter* and to solve a greater number of photometrical problems, Arago undertook, first, to prove experimentally the law of the *square of the cosine*. For this it was requisite to know, as Arago remarks, the ratios of the reflected and transmitted portions of a ray of light falling on a glass plate with parallel surfaces, for a certain number of different angles of incidence. Arago found, by a method not particularly described, the following ratios:

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- (1) Compt. Rend. XXXI, 887.
 - (2) Sill. Am. J. [2] VII, 375.
 - (3) Compt. Rend. XXXI, 851.
 - (4) Compt. Rend. XXXI, 618; Instit. 1850, 298, 345.
 - (5) Instit. 1850, 365.
 - (6) Compt. Rend. XXX, 305, 365, 425, 489, 617, 757; XXXI, 665; Instit. 1850, 89, 105, 132, 137, 161, 193, 361, Arch. Ph. Nat. XIII, 303, 307; XIV, 36.

Inclination to the glass plate.	Reflected light.	Transmitted light.
4° 32'	4	1
7° 1'	2	1
11° 8'	1	1
17° 17'	$\frac{1}{2}$	1
26° 38'	$\frac{1}{4}$	1

Photometric investigations.

A different method of proceeding gave Arago the ratios for inclinations of the incident-ray greater than 26°. After he had fully established by these data the law of the *square of the cosine*, he applied it in the following manner to graduate a polarimeter, constructed of glass plates with parallel surfaces. He employed a plate of rock crystal, cut parallel to the optical axis, to reduce to a neutral condition arbitrary portions of a fully polarized ray, easily to be calculated by the law of the square of the cosine. He then examined under what angle each of these rays must pass through a glass pile, consisting of several parallel plates, to be fully neutralized, and he formed these data into a table, which serves for very different optical objects. Amongst other things, Arago shows how the height of a single cloud in a clear sky may be determined by the degree of polarization of its light; how the brightness of the middle of the disc of the sun or moon may be compared with that of the edge, of a darker place or spot with a brighter, or the ash-coloured light of the portion of the moon not directly illuminated by the sun, with the brightness of the shining parts. He shows, farther, how the light lost by reflection at mirrors of platinum, steel, and speculum metal may be determined, and that the light lost on total reflection does not amount, as Bouguer believed, to one-quarter or one-third of the whole quantity of light, but at most to one-hundredth.

With respect to the sensitiveness of the polariscope, Arago finds that it gives indications when one-eightieth of the incident light is polarized; this number holds good on the average for eyes unfatigued by observation.

Arago has expressed his opinion that the rays from the middle of the sun's disc would exercise a stronger chemical action than those from the edge. Nièpce de St. Victor(1) found this confirmed by some twenty photographic pictures of the sun's disc. As the negative picture always turned out completely black, when made with gallic acid, even if a very small aperture of the object glass was uncovered for only an instant, Nièpce allowed the picture to be formed under the immediate influence of the sun without gallic acid, upon a film of albumin on glass, which took place in from five to ten seconds. The difference of intensity between the middle and edge was very striking.—By applying the most powerful accelerating agents, Nièpce obtained in twenty seconds a sharp picture of the moon's disc, which,

(1) Compt. Rend. XXX, 709; Iustit. 1850, 178.

* * *
New
theory of
light.

without any application of the heliostat, appeared still circular. In thirty seconds the oval form of the picture became apparent.

New Theory of Light.—E. B. Hunt(1), erroneously supposing that the equal velocity of propagation of rays of different colours has been proved by experiment, and consequently that the wave-theory is insufficient to explain the phenomenon of light, has attempted to establish a new theory of light, which may be regarded to a certain extent as a 'mediation of the Newtonian and Huyghenian hypotheses. According to Hunt, the light is propagated in waves of ether, which for the different colours contain unequal masses of vibrating ether in a state of condensation. The refraction of light arises from the attraction of the material portions on the condensed waves of ether.

Theory of Light.—Cauchy has made a great number of important contributions on the mechanics of the motion of ether; we shall make special mention of those which more particularly correspond to the object of this Report. One investigation of Cauchy(2) has for its object to explain, in a generally intelligible manner, the way in which the mathematical proof of the transverse vibration of ether is attained, and also the equation which expresses the connection between the time of vibration of an element of ether and the length of a wave, and from which the laws of dispersion are deduced. In a second communication, Cauchy(3) remarks that his formulæ, given in the year 1839(4), for the reflection of light by transparent and opaque bodies, completely agree with Arago's photometric results (See p. 84). —Cauchy(5), however, treats the problem of reflection and refraction anew, in several consecutive papers, in a more general manner, so that the formulæ for the phenomena of reflection are equally applicable to single and double refracting media. In the latter case, the result follows that the wave-surface for the ordinary ray in uniaxal crystals is not necessarily a sphere, but may be an ellipsoid of revolution, like that of the extraordinary ray, yet so that the axes of revolution of both ellipsoids coincide with one another and with the optic axis. The reflection and refraction at plates cut perpendicular to the optical axis follow the law discovered by Fresnel, if the vibrations forming the ray are perpendicular to the plane of incidence; except that when the wave-surface of the ordinary ray is an ellipsoid, the angle of refraction in Fresnel's formulæ must be replaced by the angle which the optical axis makes with the normal to the refracted wave.—Cauchy especially points out one consequence of his theory, namely, that in reflection at double refracting media, from a ray polarized

(1) Sill. Am. J. [2] VII, 364; *Forriep's Tagesber.* (Phys. and Chem.) 1850, No. 178, p. 117; No. 180, p. 121; No. 186, p. 129.

(2) *Compt. Rend.* XXXI, 812; *Instit.* 1851, 4.

(3) *Compt. Rend.* XXX, 465; *Instit.* 1850, 139.

(4) *Compt. Rend.* IX, XXVIII, 2.

(5) *Compt. Rend.* XXXI, 112, 160, 257, 297, 338, 532, 666, 766; *Instit.* 1850, 386.

either in, or perpendicular to, the plane of incidence, two components in general proceed, the one polarized in, the other perpendicular to, the plane of incidence, and that the reflected ray (since both the components undergo at the same time a change of phase) is elliptically polarized. The theory indicates that this phenomenon becomes especially perceptible when a ray, consisting of vibrations in the plane of incidence, falls on a plate of an uniaxial crystal cut parallel to the optical axis, at an angle whose tangent differs little from the ratio of the sines of the angles which the refracting surface makes with the incident and refracted waves.—Cauchy has, in conjunction with the younger Soleil, and by means of the reflection apparatus by Jamin, experimentally verified the phenomenon in question.

In an investigation on the motion of light in uniaxial crystals, Cauchy(1) finds that the two rays which are propagated at small inclinations to the optical axis are elliptically polarized, and indeed so that the major axes of the two ellipses are perpendicular to one another. But the rays which proceed perpendicularly to the optical axis are said also in general to be elliptically polarized, and Cauchy wishes that physicists would direct their attention to this result, which is not as yet experimentally verified.

The difference of path of two rays of light which have passed through a double refracting plate with parallel surfaces, is deduced by Cauchy(2) in the following manner. Let c be the thickness of the plate, i the angle of incidence, r the angle of refraction, v and v' the velocities of the incident and refracted waves, then, as is known, $\frac{v'}{v} = \frac{\sin r}{\sin i}$. Let h be a certain length measured on the refracted ray, which is travelled over by the refracted wave in the same time t in which the incident wave passes over the space s , lastly, let s' be the projection of h on the direction of the incident ray, then $h = c \sec r$, $t = \frac{h}{v}$, $s = vt$, then $s = h \frac{\sin i}{\sin r} > s' = h \cos(i-r)$. The difference of path of the emergent and incident waves, if the latter have moved forward during the time t with the velocity v , is, therefore, $s - s' = c \frac{\sin(i-r)}{\sin r}$. For the wave of the extraordinary ray we have,

in like manner, $s - s'' = c \frac{\sin(i-r')}{\sin r'}$, from which the difference of path of the ordinary and extraordinary rays is $\delta = s' - s'' = c \frac{\sin i \sin(r-r')}{\sin r \sin r'}$.

For the case of a plate of rock crystal cut perpendicularly to the optical axis, we have (δ_0 being the value of δ for $r=0$) as a first

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approximation, $\delta^2 = \delta_0^2 \cos^2 r + \epsilon^2 \sin^2 r$, in which $\frac{\epsilon}{\delta_0}$ is the difference between the coefficients of refraction of the extraordinary and ordinary rays.

On the origin of circular polarization in single refracting media, as for instance, in many fluids, Cauchy(1) has proposed a new hypothesis, and based on the same a series of mathematical investigations. He shows what changes the differential equations for the motion of the ether undergo, on the supposition of material molecules distributed in small number through the mass of the ether. Cauchy compares the influence of these molecules on the paths of the atoms of ether, with the disturbances which the orbits of the planets undergo from the influence of a neighbouring planet. If the ether is enclosed in a crystallized medium, the elliptical orbits, which the ether-atoms of a ray describe, undergo disturbances of two kinds; one kind periodic, but whose period does not depend on the time, but on the co-ordinates of the material molecules, and another kind corresponding to the secular disturbances of the planetary orbits: these last produce the phenomena of circular polarization. Under all these circumstances, two elements of the motion of the ether remain unaltered, the length of the wave and the time of vibration.

In his investigation into the reflection of light at such isophanous media as cause the plane of polarization to rotate, Cauchy(2) arrives at results, of which he speaks in the following manner: When a single plane polarized ray falls on the plane surface of a transparent isophanous medium, the incident ray may always be conceived to be resolved into two components, polarized respectively in, and perpendicular to, the plane of incidence. These components acquire by reflection a difference of phase, which increases from 0 to π , within a small range, in the neighbourhood of the direction of principal(3) incidence, so that the reflected ray is in most cases plane polarized, and only within that narrow range acquires elliptic polarization, which is exclusively due to the difference of phase of the two components.

When the isophanous transparent medium has the property of producing circular polarization, the formulæ for the reflected and refracted ray become more complicated; they depend on the two coefficients of refraction of the oppositely vibrating circular rays, and the coefficient of ellipticity.—If the incident ray is polarized in the plane of incidence, the reflected ray is so too, if the mean angle of refraction is half a right angle. In every other case, the reflected ray is elliptically polarized, and may be considered as the resultant of

(1) Compt. Rend, XXX, 17, 33.

(2) Compt. Rend. XXXI, 225; Inst. 1850, 265.

(3) Cauchy gives the name of the direction of principal incidence to that in which the difference of phase of the two components of the reflected ray is $\frac{\pi}{2}$.

two components, polarized respectively in, and perpendicular to, the plane of incidence. The first has the same intensity as if the isophanous medium had the power of turning the plane of polarization, but with a constant mean coefficient of refraction; the second is extremely feeble, and proportional to the difference of the two coefficients of refraction.—The same phenomenon of elliptic polarization, though with the ratio of the intensities of components reversed, takes place in the reflected ray; when the incident ray is polarized perpendicularly to the plane of incidence, and the angle of incidence differs from that of principal incidence. If the ray is incident at the angle of principal incidence, the tangent of which is nearly equal to the mean coefficient of refraction, the reflected ray is plane polarized, but in a plane which makes an acute angle with the plane of incidence. The tangent of the azimuth is proportional to the difference of the two coefficients of refraction, and inversely proportional to the coefficient of ellipticity. Cauchy directs the attention of experimenting physicists to the circumstance, that by reflection at such isophanous media, at the angle of principal incidence, the azimuth of the polarization passes from a right angle to an acute angle.

Cockle(1) makes a remark on the previously mentioned paper of Airy(2), on the motion of ether under the influence of magnetism, and expresses his opinion that the particles of ether experience a resistance similar to friction from the particles of the glass.

Measurement of the Velocity of Light.—Arago(3) communicates historical notices of the experiment, by means of which he expected to prove the truth of the hypothesis of vibrations, as distinguished from that of emission, by showing, by means of Wheatstone's mirror, that light moves more slowly in highly refracting media than in air. He specifies what improvements in the apparatus had been attempted by him, in conjunction with the younger Breguet, and what had been proposed by other physicists, especially by Bessel, and adds, that in consequence of the present state of his sight, he must relinquish to other inquirers the carrying out of this experiment, and with great probability that this may be expected from Fizeau and Foucault.

Velocity of Light in Air and Water.—Foucault(4) has actually performed the experiment projected by Arago for showing that the velocity of light in water is actually less than in air, as the undulatory theory requires.—The most ingenious apparatus, which served for this object, consists substantially of the following parts. A beam of sunlight or electrical light passes through a square opening, and

(1) Phil. Mag. [3] XXXVI, 294.

(2) Annual Report for 1847-8, I, 191.

(3) Compt. Rend. XXX, 489.

(4) Compt. Rend. XXX, 551; Instit. 1850, 146; Pogg. Ann. LXXXI, 434; Arch. Ph. Nat. XIV, 137.

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immediately behind that, through a grating of vertical platinum-wires, eleven to the millimetre. It then falls on an achromatic lens of long focus, which is placed at double its focal distance. Before the image of the grating is formed behind the lens, the light is received by one of Wheatstone's revolving mirrors, and carried round with double the angular velocity of the mirror. For a small portion of its path it falls on a concave mirror whose centre of curvature is in the axis of rotation of the small mirror, it is thence reflected to the small mirror and so back to the grating itself. In order to observe it without intercepting the direct beam of light, a plate of glass is placed near the grating obliquely, so that the images of the wires formed by its two surfaces are superposed, and the image thus formed is examined with a powerful cyc-piecc. For more than thirty revolutions a second of the rotating mirror, the image ceases to be interrupted, but appears quite at rest. Since the light which returns to the grating has undergone two reflections at the revolving mirror, which are separated from one another by the time which the light requires to traverse twice the distance between the revolving and concave mirrors, the image will be somewhat displaced in the direction of rotation if the angular motion of the revolving mirror in this time cannot be regarded as insensible. With a length of four metres for the double distance, a velocity of from 600 to 800 revolutions in a second, gave a displacement of the image of from two to three-tenths of a millimetre, which was measured by means of a micrometer scale divided to one-tenth of a millimetre, which served as a vernier to the wires at a distance of one-eleventh of a millimetre.—To measure the velocity of light in water, a column of water three metres long, in a conical metal tube enclosed at both ends with plates of glass, was interposed between the concave and revolving mirrors.

To set the mirror in quick rotation, Foucault employed a steam-turbine, constructed by himself, which allowed the velocity of the mirror to be altered at pleasure from 30 to 800 revolutions, to be kept constant at a certain amount, and to be accurately measured. The measurement was effected by the note which the steam formed in issuing through 24 holes in the revolving disc, as in the Siren, and by determining the number of beats or pulses which the note formed with a tuning-fork, especially adjusted for the purpose.

Up to the present time, Foucault has obtained with the apparatus just described only one decided result, namely, that the displacement of the image after passing through the air was less than after passing through water, which proves *that the velocity of light in water is less than in air*. Besides this, when proper regard is had to the distances traversed in water and in air, the displacement is said to be proportional to the indices of refraction.—Foucault believes that he will succeed with the same apparatus in measuring the velocity of the rays of heat, by the displacement of the fringes of heat which accompany the

fringes of light, and which he expects to be able to show with a small thermometer.

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light in air
and water.

Fizeau and Breguet(1) have also proved, by perfectly conclusive experiments, that light moves more quickly in air than in water, of which they had made an announcement, simultaneously with the publication of the preceding one of Foucault(2).—Close before the object glass of a telescope, they placed a revolving mirror, capable of 2000 revolutions in a second. The light, which entered the telescope from one side, was reflected by a right-angled prism, placed in the focus on to the revolving mirror, from this on to a fixed reflector, and by this it was reflected so as to retrace its way into the telescope. With no more than 400 or 500 revolutions of the mirror, there was a sensible displacement of the reflected light compared with the incident; with 1500 revolutions per second this displacement was very apparent, and quite equal for two luminous points, when the respective rays between the revolving and fixed mirrors had passed through spaces in air and water in the ratio of 4:3. When this ratio of the lengths of paths was reversed, the displacements were as 9:16.

Interference for Great Difference of Path.—Fizeau and Foucault(3) have published the second part of their memoir on interference for large difference of path(4). In it they describe the state of polarization exhibited by the different parts of the pure spectrum of a ray which has passed through a double refracting plate, without the ordinary and extraordinary rays being afterwards brought to interference by means of an analyzing apparatus. If the principal section of the double refracting plate makes an angle of 45° with the original direction of vibration, plane polarization is found in the places where the analyzing Nicol's prism would show dark lines(5); we will call the space between two such places, an interval. In the middle of each interval, where when analyzed the maximum intensity of light would occur, the polarization is also plane, at right angles to the before-mentioned direction: at the quarter and three-quarter points of each interval the light is circularly polarized; and in other parts of the interval, namely, from 0 to $\frac{1}{4}$, $\frac{1}{4}$ to $\frac{1}{2}$, $\frac{1}{2}$ to $\frac{3}{4}$ and $\frac{3}{4}$ to 1 the light is elliptically polarized, and in fact in the first half of each interval the vibrations have an opposite direction to that in the second half.—With a plate of rock crystal cut parallel to the axis, which Fizeau and Foucault employed, 600 such intervals were contained in one spectrum; the same contained therefore 1200 plane polarized rays, and 600

(1) *Compt. Rend.* XXX, 771; *Instit.* 1850, 194; *Arch. Ph. Nat.* XIV, 207; *Pogg. Ann.* LXXXII, 124.

(2) *Compt. Rend.* XXX, 562; *Instit.* 1850, 148; *Arch. Ph. Nat.* XIV, 145; *Pogg. Ann.* LXXXI, 442.

(3) *Ann. Ch. Phys.* [3] XXX, 146.

(4) For their first investigation, see *Annual Report for 1849*, III, 67.

(5) *Ibid.*

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circularly polarized in one direction, 600 in an opposite direction, and all the intermediate rays were elliptically polarized in very different ways. If we conceive all these rays united again into one white ray, we may form an idea how complicated must be the motion of the particles of ether which propagate a ray having thus passed through a double refracting plate.—As the phenomena farther described by Fizeau and Foucault only involve consequences which every one can easily deduce for himself from the laws of composition of ethereal vibrations—as, for instance, the nature of the spectrum, when the principal section of the double refracting plate makes with the original direction of vibration an angle different from 0° , 45° or 90° , or when the ray has passed through a plate of rock crystal cut perpendicular to its axis, or if one or two Fresnel's rhombs are used—we do not enter farther on these points. We only add, that Fizeau and Foucault have succeeded, under especially favourable circumstances, in extending the range of interferences to still greater differences of path, than was the case at the time of the publication of the first part of their memoir(1). By the interference of rays which had been reflected at the two surfaces of thin plates of glass, they obtained dark stripes for the following differences of path :

Thickness of the plate	mm	mm	mm
Difference of path in wave-lengths for the ray F	0.671	0.903	1.029
" " " " G	4256	5728	6227
" " " " "	4821	6489	7394

Here is proof that the oscillations in a ray at the distance of 8000 wave-lengths preserve a continuous uniformity and regularity, so as to sensibly interfere with one another.—3000 vibrations, however, will be completed in the $\frac{1}{60000000}$ part of a second, so that we cannot conclude from this that the oscillations for any sensible fraction of a second preserve the same character.

Diffraction of Light.—Lord Brougham(2) has made experiments on the diffraction of light, which must be considered as a continuation of a work(3) commenced by him upwards of fifty years ago. He seems, however, not to have followed carefully the advances which optics have made in this interval, as he otherwise would hardly have assumed a difference between the phenomena of diffraction which depend on interference (such as the fringes in the shadow of a thin body) and those which have other causes (fringes on the luminous side). Facts such as that there are more than three diffraction fringes, that it is indifferent whether the body casting a shadow has a sharp or rounded edge, scarcely required an experimental proof. Lord Brougham is at especial pains to show that light which has been inflected by passing

(1) Comp. Annual Report for 1849, III, 67.

(2) Phil. Trans. for 1850, I, 235; Phil. Mag. [3] XXXVI, 466; Compt. Rend. XXX, 43, 47, 67; XXXI, 845; Instit. 1850, 34, 40.

(3) Phil. Trans. for 1797.

an edge, has acquired the property of being less easily inflected in the same direction by a second edge, while, on the contrary, it is more easily inflected in the contrary direction. This disposition to inflection in one direction, or polarization, is said to be inversely as the distance from the first position of inflection.—Although Lord Brougham disclaims in the first instance being either a follower or opponent of the theory of undulations, but will be a “Rienist” yet he falls on every occasion into the phrasology of the Newtonian hypothesis, which was the prevalent one in his youth, and on this account we shall be excused entering farther on his elaborate and extended investigation.

Diffraction
of light.

A paper by Stokes(1) on the diffraction of light, in which the author treats the motion of the ether as that of an elastic solid, has only been communicated in abstract. We regret that through the want of a more ample publication we are not in a condition to estimate the paper properly, the more so, as the author is led by theoretical considerations to an experiment, from which he believes that he can decide that the vibrations in polarized light are perpendicular to the plane of polarization(2).

Brewster(3) refers to an observation published by him in 1830(4), of the coloured fringes exhibited by a steel surface, on which extremely fine grooves have been engraved by a diamond. The coloured fringes here meant by Brewster are said to be at right angles to the grooves. An explanation of these on the undulatory theory has not been given by any one, notwithstanding his especial challenge. The light of those fringes exhibits a peculiar state of polarization, and Brewster intended to study the dependence of this state on the angle of incidence, and the azimuth of the plane of incidence; but as insuperable difficulties lay in his road, he confined himself to communicating the following results, which he obtained from a grooving made on steel by Barton. This consisted of 6 systems of grooves, of from 315 to 10,000 to the inch. The transverse fringes he saw only on the systems of from 2500 to 10,000 to the inch, the phenomena of polarization only on the latter. When common white light was reflected at this, the reflected ray was white at an incidence of 90° , a greenish-blue at 0° , and somewhat purple at 30° , and this for all azimuths of the plane of incidence as compared with the grooves. But when this azimuth was 90° , the reflected ray contained a red portion which was polarized in the plane of incidence, and a blue portion polarized in a perpendicular plane. When the angle of incidence differed considerably from 30° , the polarization was diminished. When the azimuth of the plane of incidence was diminished, the directions of polarization remained on

(1) Phil. Mag. [3] XXXVI, 235.

(2) Comp. Annual Report for 1849, III, 71—73.

(3) Compt. Rend. XXX, 496; Instit. 1850, 137.

(4) Phil. Trans. for 1830.

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of light.

longer parallel and perpendicular to the plane of incidence, and when the azimuth was 0° the red ray was polarized perpendicularly to the plane of incidence, and the blue ray in that plane.

*From these facts, in connection with those contained in the previously mentioned earlier publication, Brewster draws the following conclusions :

1. When homogeneous light falls on a very small reflecting surface, there are frequently four or five different angles of incidence at which no light at all is reflected. Between these there are maxima of reflection.

2. The number of these angles of incidence is increased as the reflecting surface becomes smaller; the angles of incidence are somewhat smaller for the blue than for the red rays.

3. The direction of polarization of the reflected rays depends on the direction of the grooves (the bounding lines of the small reflecting surfaces).

4. When light is reflected from a surface of unlimited length but very small breadth, the degree of polarization and its azimuth with reference to the plane of incidence, depend on the length of the line in which the plane of incidence cuts the reflecting surface.

To what extent the magnitude of the spaces between the reflecting strips is important, and whether maxima of polarization exist in the different fringes, Brewster has not yet ascertained.

Wilde(1) in a communication on the theory of diffraction phenomena, has first given an historical review of the progress towards the solution of this problem. He next gives the elements of the mechanics of ethereal vibrations, which he might have presupposed as generally known. He then develops the general formulæ for the composition of several systems of waves, whose differences of paths increase in arithmetical progression, and from these deduces the phenomena of diffraction through a slit, through an opening in the form of a trapezium, a parallelogram and a triangle, as well as through a row of similar and equidistant openings, and through several rows of such openings. Wilde follows here exactly the method employed by Schwërd(2) in taking the incident ray always perpendicular to the surface of the screen. The developments and results obtained by Wilde are, therefore, to be regarded throughout as only a specializing of the work of Schwërd.—In the development of the phenomena of diffraction through a circular aperture only, Wilde finds it more advantageous to solve the problem by Knochenhauer's(3) process, by the differential calculus.

Reflection of Light. Mirrors Inclined at an Angle.—Bertin(4), in an

(1) Pogg. Ann. LXXIX, 75, 202.

(2) Schwërd, *die Beugungserscheinungen*, &c., Mannheim, 1835.

(3) Knochenhauer, *die Undulationstheorie*, S. 22.

(4) Ann. Ch. Phys. [3] XXIX, 257; Pogg. Ann. LXXXII, 288.

investigation concerning mirrors placed at an angle, arrives at the following laws: 1. When the angle between the mirrors is the n th part of four right angles, the number of images, including the object itself, is $n + 1$. This number is reduced to n when n is even, and when the object is in the bisector of the angle between the mirrors. 2. When the angle is contained in four right angles between n and $n + 1$ times, the number of images is at least $n + 1$, it may be $n + 2$ if the luminous point is properly situated.

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Reflection of Light by Transparent Bodies.—The paper of Jamin on the reflection of light by transparent bodies, already mentioned in preceding Reports(1), is now fully before us(2), so that we can obtain a complete insight into the course of this remarkable investigation.—After Jamin had convinced himself by preliminary experiments that the components of a ray of polarized light in, and perpendicular to, the plane of incidence, were generally not only reflected with unequal intensity at the surfaces of transparent bodies, but also that the intensity of the first does not entirely vanish for any angle of incidence; and farther, that the nodes of the waves of one component were displaced relatively to those of the other; finally, that in the neighbourhood of the so-called angle of complete polarization this displacement amounted to a quarter of a wave-length, just as in reflection at a metallic surface,—he undertook to measure the difference of phase as well as the ratio of the intensities for a great number of transparent substances and for different angles of incidence.

Jamin owes the most satisfactory results to the careful arrangement of his apparatus. The reflecting surface was placed perpendicularly over the centre of a graduated circle, two circles carried Nicol's prisms of perfect quality, whose position in azimuth was read off on two vertical circles. A sunbeam entering the chamber from a heliostat was completely polarized by the first Nicol's prism before it reached the reflecting surface. By means of the second Nicol's prism, the azimuth of complete polarization of the reflected ray could be ascertained, and thence the ratio of the intensities of the two components could be deduced. When the angle of incidence was near that of principal incidence, this was not effected till the difference of phase of the two components which was then introduced, was removed again, and the elliptic polarization thereby reduced to plane polarization. This was effected by Babinet's compensator, already described in the Report for 1849 (page 71). Two vertical threads at a distance of one millimetre indicated the position in the middle of the field of view, at which the two prisms of quartz in the normal position of the moveable prism were of equal thickness. When the incident light was polarized at an angle of 45° in azimuth, and analyzed by the

(1) Annual Report for 1847-8, I, 133; Annual Report for 1849, III, 71.

(2) Ann. Ch. Phys. [3] XXIX, 263.

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Nicol's eye-piece, a black fringe was seen between the two wires. Similar fringes, left and right of the first, correspond to a retardation of half a wave-length in the ordinary or extraordinary ray. The division on the micrometer-screw by which the one prism was moved, allowed $\frac{1}{100}$ mm to be measured. A displacement of 12.70 micrometer divisions replaced the middle fringe by the next in order to the right or left. It is clear how, by means of this apparatus, a difference of phase of the vertical and horizontal vibrations could be compensated and measured at the same time, since the direction of this vibration is not in the least altered by the compensator.

If in the Nicol's eye-piece the azimuth of polarization is found to be β , that of the incident light being α , the ratio of the intensities of the components of the reflected ray polarized parallel and perpendicular to the plane of incidence $\frac{J}{J'} = \frac{\tan \beta}{\tan \alpha}$. A displacement of d divisions on the compensator, to restore the plane polarization, indicates a difference of path $a = \frac{\lambda}{2} \cdot \frac{d}{12.7}$, and this is positive or negative, that is, the vibrations in the plane of incidence are behind or before those perpendicular to it, according as the displacement of the prism is in the one direction or the other.—When the plane polarization is restored, the difference of path $a + a$ is a multiple of $\frac{\lambda}{2}$; the part a , which depends on the compensator, varies between the limits 0 and $\frac{\lambda}{2}$; the part a , which arises from reflection, increases, according to Jamin, from $\frac{\lambda}{2}$ to λ , as the angle of incidence increases from 0° to 90° . By considerations, for which we refer to the memoir itself, Jamin deduces that the differences of path pass either through the values $+\lambda$, $+\frac{3\lambda}{4}$, $+\frac{\lambda}{2}$, or $-\lambda$, $-\frac{3\lambda}{4}$, $-\frac{\lambda}{2}$, as the angle of incidence diminishes from 90° to 0° . The *principal incidence* is that angle of incidence for which the difference of path is $\pm \frac{3\lambda}{4}$. It must appear strange, that for direct incidence, where there is no definite plane of incidence, the two components perpendicular to one another should acquire a difference of phase of half a wave-length, seeing they fall on the reflecting surface under exactly similar circumstances. Yet this is the simplest expression of the phenomenon, for, as Jamin had the goodness to explain to us in a written communication, the plane of polarization of a ray polarized at $+45^\circ$ in azimuth, coincides, after reflection at an angle of incidence of 90° , with the plane of polarization of the incident ray, and then, as the angle of incidence decreases, the azimuth passes gradually through 0 to -45° , and attains this

limit at direct incidence. Here, says Jamin, the same difference presents itself as when the vibration of a ray polarized at 45° is considered first in the direction of its propagation, then in the opposite direction; the azimuth will then, also, seem to have turned through a right angle.

The eye is just in this position with reference to the reflected and incident ray at direct incidence, and there is, therefore, no need to suppose any *real* change of azimuth, and, consequently, any *real* difference of path of the two components.

All substances whose coefficient of refraction is greater than 1.46 exhibit *positive reflection*, that is, the ray vibrating in the plane of incidence lags behind the other component. And with this the limits, within which in the neighbourhood of principal incidence elliptic polarization is perceived, generally approach closer together the smaller the coefficient of refraction is. In metals the change of the difference of path from λ through $\frac{3}{4}\lambda$ to $\frac{\lambda}{2}$ is uniform, from an incidence of 90° to one of 0° , on the other hand, differences of path from 1.1λ to 1.9λ lie between the following angles of incidence:

				Difference.
Realgar	$n=2.454$	57°	and 77°	20°
Blende	$=2.371$	62°	„ 72°	10°
Flint-glass	$=1.714$	57°	„ 62°	5°
Crown-glass	$=1.487$	$55^\circ 20'$	„ $56^\circ 50'$	$1^\circ 30'$

In substances whose coefficient of refraction $=1.46$, these limits become so close that the change of the difference of phase from λ to $\frac{\lambda}{2}$ appears to take place suddenly at principal incidence. To these bodies alone are Fresnel's formulæ of reflection applicable.

Lastly, bodies of still lower refractive power exhibit *negative reflection*, the ray vibrating in the plane of incidence is accelerated.

Cauchy's reflection formulæ, which give for the ratio of the intensities of the two reflected components

$$\frac{J^2}{J'^2} = k^2 = \frac{\cos^2(i+r) + \epsilon^2 \sin^2 i \sin^2(i-r)}{\cos^2(i-r) + \epsilon^2 \sin^2 i \sin^2(i+r)} \quad (1),$$

agree most perfectly with the results of experiment. It is only when the coefficient of ellipticity ϵ can be taken as zero that they pass into Fresnel's formulæ, and then these last are applicable. — The difference of phase is

$$\delta = \delta' + \delta'' + \begin{cases} \pi & \text{if } i+r < 90^\circ \\ 0 & \text{if } i+r > 90^\circ \end{cases}$$

$$\tan \delta' = \epsilon \sin i \cdot \tan(i+r); \quad \tan \delta'' = \epsilon \sin i \cdot \tan(i-r).$$

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The difference of phase δ becomes $\frac{3\pi}{2}$, when the angle of incidence i satisfies the condition

$$\tan (i+r) = \frac{1}{\epsilon^2 \sin^2 i \tan (i-r)} \quad (2),$$

from which the angle of principal incidence could be calculated, if the coefficients of refraction and ellipticity were known.

The law discovered by Brewster, and confirmed by Seebeck, requires that for the angle of greatest polarization $i+r = \frac{\pi}{2}$. This angle i coincides with the angle of principal incidence in those substances only to which Fresnel's formulæ are applicable. With sensibly elliptic polarization $i+r = 90^\circ$, and

$$\tan \delta = \frac{-1}{\epsilon \sin i \tan (i-r)}$$

give a value for δ which is indeed very nearly equal to $\frac{3\pi}{2}$, but yet somewhat greater. Jamin has not been able to prove this difference experimentally.

To deduce n and ϵ , the two constants of theory from the angle of principal incidence, and the ratio k of the amplitudes, which magnitudes may be ascertained by observation, equations (1) and (2) are employed. If the value of $\epsilon^2 \sin^2 i$, given by (2), is substituted in (1), we have

$$k^2 = \frac{\sin 2(i+r)}{\sin 2(i-r)} \quad \text{or} \quad \tan 2r = \frac{k^2 - 1}{k^2 + 1} \tan 2i,$$

so that the value of r for any value of i , and thence n , may be found. Equation (2) is then used to calculate ϵ .

The following table contains the constants determined by Jamin for a series of solid bodies; n is the calculated, n' the observed coefficient of refraction.

POSITIVE SUBSTANCES.	J	k	ϵ	n	n'
Selenium	68° 5'	0.1750	0.1200	2.605	—
Pit-coal	59° 17'	0.1022	0.1158	1.701	—
Tourmaline	58° 25'	0.0829	0.0864	1.645	1.668
Plumbic ochre (Bleiglätte)	64° 0'	0.0945	0.0825	2.076	—
Realgar	67° 26'	0.0850	0.0791	2.454	2.420
Calc spar (perpendicular to its axis)	59° 0'	0.0591	0.0606	1.675	1.654
Anthracite	59° 42'	0.0545	0.0548	1.720	—
Blue strass	57° 53'	0.0437	0.0492	1.597	—
Flint glass (A, Mathiessen)	59° 14'	0.0349	0.0365	1.683	—
Arsenious acid	59° 24'	0.0349	0.0332	1.692	—
Zinc blende	67° 6'	0.0420	0.0296	2.371	2.369
Flint glass (B, Faraday)	60° 16'	0.287	0.0285	1.755	—

POSITIVE SUBSTANCES.	J	k	ε	n	n'	Reflection of light by transparent bodies.
Antimony glass	63° 34'	0.0290	0.0258	2.013	2.010	—
Borate of lead	61° 16'	0.0266	0.0256	1.825	1.866	—
Asphaltum	57° 38'	0.0250	0.0252	1.579	—	—
Cornelian	56° 53'	0.0213	0.0245	1.534	—	—
Green glass	56° 46'	0.0199	0.0218	1.527	—	—
Glue	56° 28'	0.0184	0.0199	1.509	1.520	—
Resin of aloes	58° 18'	0.0181	0.0197	1.619	1.634	—
Diamond	67° 30'	0.0190	0.0180	2.434	2.439	—
Flint glass (C, Guinand)	59° 44'	0.0180	0.0170	1.714	1.710	—
Topaz	58° 36'	0.0154	0.0161	1.638	1.638	—
Colourless strass (D)	57° 53'	0.0133	0.0158	1.593	1.580	—
Beryl (perpendicular to the axis)	57° 21'	0.0133	0.0145	1.560	1.598	—
Flint glass (E)	58° 12'	0.0114	0.0120	1.613	1.614	—
Garnet	60° 30'	0.0111	0.0110	1.767	—	—
Quartz	56° 50'	0.0102	0.0112	1.530	1.547	—
Amber	56° 50'	0.0098	0.0107	1.530	1.547	—
Diopside	54° 2'	0.0095	0.0106	1.378	—	—
Green strass	58° 36'	0.0084	0.0089	1.638	1.620	—
Copal	56° 48'	0.0084	0.0092	1.528	1.535	—
Strass (deep rose-coloured)	58° 17'	0.0083	0.0088	1.618	1.618	—
Red glass	56° 8'	0.0076	0.0085	1.490	—	—
Gum Arabic	56° 3'	0.0071	0.0082	1.480	1.476	—
Flint glass (F)	57° 40'	0.0076	0.0082	1.579	1.574	—
Alum	55° 22'	0.0065	0.0075	1.448	1.457	—
Glass	56° 5'	0.0060	0.0075	1.487	—	—
Colophony	55° 15'	0.0086	0.0070	1.545	1.543	—
NEUTRAL SUBSTANCES.						
Alum (perpendicular to axis of octohedron)	55° 0'	0.0000	0.0000	1.428	—	—
Menilite	56° 0'	0.0000	0.0000	1.482	—	—
NEGATIVE SUBSTANCES.						
Resinous silex (blue)	55° 13'	0.0052	0.0059	1.439	—	—
Fluorspar	55° 15'	0.0084	0.0097	1.441	—	—
Hyalite	54° 52'	0.0064	0.0074	1.421	—	—

An objection to the trustworthiness of the results just mentioned, is grounded on the assumption that the surfaces which were the subjects of investigation had been put in an artificial state of constraint by the mechanical process of polishing, and that on this account the phenomena of reflection also could not remain natural; and, in fact, Seebeck(1) has found, by his measurements of the angle of polarization, that such influences make themselves sensibly felt. But, independently of the regularity of the results obtained, Jamin has studied the phenomena of reflection at a number of natural cleavage surfaces, with similar results. Nevertheless, he did not consider it superfluous to render his results completely incontrovertible by observations on fluids(2); and, in fact, by these investigations, of

(1) Pogg. Ann. XX, 27; XXI, 290; XXII, 126; XXXVIII, 276; XL, 462.

(2) Compt. Rend. XXXI, 696; Instit. 1850, 369; Pogg. Ann. LXXXII, 149; more in detail (1851) Ann. Ch. Phys. [3] XXXI, 165.

Newton's
rings.

which we shall be able to make a more complete communication in our next Report, the preceding laws of reflection have been thoroughly confirmed.

Stokes(1) gives several means for showing that in reflection at metals the two principal components, that is, the rays polarized respectively in and perpendicular to the plane of incidence, acquire a difference of phase.

Newton's Rings.—Wilde(2) has lately undertaken observations and careful measurements on the phenomena of Newton's coloured rings, and has arrived at an opinion of the nature of the central dark spot and the breadth of the first bright ring, which differs from the explanation hitherto given.—The instrument with which Wilde produced and measured the rings is constructed on the principle of Jerichau's *Gyreidoscope*(3), and named by Wilde the *Gyreidometer*.—A lens of small convexity is moved by a micrometer screw which reads to the ten-thousandth of an inch, in a horizontal direction, and by that means pressed against a glass plate with parallel surfaces, which is inclined at an angle of 34.5 to the horizon. One division of the micrometer screw corresponds, therefore, to an approach of the convexity of the lens to the glass plate of one-millionth of an inch. In the direction of the reflected ray the axis of an eye-piece is placed, which carries a wire stretched in the plane of reflection, and can be moved horizontally by means of slides and micrometer screws. A motion of the ten-thousandth of an inch can be observed, and one of even the hundred-thousandth estimated with some certainty.

It is known that the difference of phase of the rays reflected at the upper and lower surfaces of a thin plate, which interfere with one another, depends not only on the differences of the paths passed over, but also on the sign of $i - r$, where i is the angle of incidence and r the angle of refraction. But since this expression has equal values but opposite signs for those two rays, the difference of phase is found by increasing the difference of paths by half a wave-length. Thus was explained the appearance of the black central spot in the system of rings of the reflected light, in the position where the difference of the paths was absolutely or nearly zero. Wilde does not deny the theoretical grounds of this explanation, but is nevertheless of opinion, that the first dark ring first appears where the thickness of the plate $= \frac{\lambda}{2}$, because then the difference of phase $= \frac{3\lambda}{2}$. He states that the rings began to lose their circular form while the centre of the system was still bright; his measurements with the gyreidometer

(1) Instit. 1850, 320; Sill. Am. J. [2] X, 391.

(2) Pogg. Ann. LXXX, 407; Phil. Mag. [3] XXXVII, 451.

(3) Pogg. Ann. LIV, 139.

farther showed that the first bright ring joined immediately the bright centre, because it was only on this hypothesis that the ratio of the bright and dark rings, indicated by theory, was confirmed by the measurement.—However trustworthy these measurements may be, yet the author of this Report has never been able to verify the first observation of the distortion of the system of rings with a bright centre; and, moreover, it might be difficult to deny that the intensity of the light from the place where the thickness of the plate

$= \frac{\lambda}{4}$ to the point of contact must, according to the previous theory,

(not contradicted by Wilde,) approach a minimum. That air must exist between the two surfaces of glass, when the phase of vibration of a ray is altered by half an oscillation, is not absolutely necessary; for the state of the ether does not change suddenly at the bounding surfaces of the glass, and has the peculiar form of transition even at the point where the last molecule of air is pressed out. That it is possible, indeed, that an actual alteration of the nature of the surface of the glass results from the pressure, Wilde has furnished an experimental proof, by showing that, at the point of the surface of a prism, where it was pressed in contact with a convex lens, a dark spot was visible in the bright field of total reflection. Here the two pieces of glass are manifestly connected, as it were, into one substance; the light goes simply through at this place; and there is no question that in a similar manner, in the middle of the dark central spot of Newton's rings, the contact can likewise be made so close that the light passes through; but the dark spot which is shown in this manner, must always be surrounded by a ring of minimum intensity of light, which rests on the previously developed theoretical grounds. Wilde may be in a position to show how the theory can be brought in unison with the assertion, that from the thickness

$\frac{\lambda}{4}$ of the film in question to the point of contact the intensity of the light does not decrease, that the origin of the darkness of the central spot is consequently to be sought *merely* in the light having passed, through at the point of contact of the pieces of glass.

Stokes (1) explains how Newton's coloured rings, when formed between the surface of a prism and a lens, nearly at the angle of total reflection, are only seen indistinctly, especially the upper half of them. In order to see them distinctly by the light of a spirit-lamp, he employed a small eye-hole, made with a needle in thin pasteboard. Stokes also remarked that the central black spot remained visible at last, when the whole field was bright with light that had been totally reflected.

Polariza-
tion by
reflection.

Polarization by Reflection.—In a ray of light which has been reflected at the angle i , the quantity of polarized light is to the whole intensity, according to Fresnel, as

$$\cos^2(i-r) - \cos^2(i+r) : \cos^2(i-r) + \cos^2(i+r),$$

where r is the angle of refraction corresponding to i . This ratio, as Arago has already remarked, is found to be the same for angles of incidence equally greater or less than the polarizing angle.—Desains(1) has offered an experimental confirmation of the formula. He caused a polarized ray to fall perpendicularly on a plate of quartz, cut parallel to the axis, the plane of polarization being inclined to the axis at an angle α ; so that, after passing through, the ratio of polarized light to the whole was that of $\cos^2 \alpha - \sin^2 \alpha : 1$, he then determined for different values of α the angle of incidence ρ , at which the ray must fall on a pile of 13 glass-plates, to be completely polarized. Finally, he employed the glass pile so graduated to depolarize a ray of light which had been reflected at a plate of black glass at different angles of incidence β , and so partially polarized. The angle ρ at which this took place, enabled him to determine the required ratio of the intensities. On the other side, this same ratio could be calculated from Fresnel's formulæ. Desains assumed the coefficient of refraction of black glass = 1.425, which gave $54^\circ 56'$ for the polarizing angle, while it was found by observation to be $54^\circ 45'$. The following are the results obtained by Desains:

Angle of incidence at black glass ° = β .	Angle of incidence for depolarization.	Ratio of the polarized light to the whole light.	
		Observed.	Calculated.
30°	36° 52'	0.420	0.413
35°	42° 31'	0.555	0.563
40°	48° 58'	0.707	0.719
70°	48° 33'	0.698	0.708
75°	41° 52'	0.539	0.536

Refraction of Light. Measurement of Indices of Refraction.—Dutirou(2) gives a detailed description of the apparatus and method which was employed in the measurement of the coefficients of refraction of different sorts of glass, the results of which have been already communicated in last year's Report(3). The apparatus consisted of a repeating circle, which was arranged on the principle of Charles' goniometer. Either the minimum deviation D was measured for the seven Fraunhofer's lines, or this was done for one ray only,

(1) Compt. Rend. XXXI, 676; Instit. 1850, 362; Pogg. Ann. LXXXII, 152; Phil. Mag. [4] I, 335; more in detail Ann. Ch. Phys. [3] XXXI, 286.

(2) Ann. Ch. Phys. [3] XXVIII, 176.

(3) Annual Report for 1849, III, 77.

and for the remainder the small angle δ alone, which, their direction made with the direction of that ray in the position of minimum deviation, was determined. The following formulæ were employed:

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$$\text{in the first case: } n = \frac{\sin \frac{1}{2} (A + D)}{\sin \frac{1}{2} A},$$

$$\text{in the second case: } n' = \frac{\sin \frac{1}{2} (A + D)}{\sin \frac{1}{2} (A + \theta)},$$

where the angle θ is determined from the equation

$$\tan \theta = \tan \frac{1}{2} \delta \cdot \tan \frac{1}{2} A \cot \frac{1}{2} (D + A - \delta).$$

All who wish to make similar determinations are recommended to study the arrangements employed by Dutirou, and the precautionary measures which he adopted. Dutirou describes, in an appendix to his memoir, an apparatus, which he has constructed and applied after an idea of Babinet, by which the coefficient of refraction of a ray corresponding to a given one of Fraunhofer's lines can be measured, even without sunlight. This apparatus, to which the name *Illuminator* has been given, consists of two horizontal tubes placed on one stand, which are inclined at such an angle that rays which have entered through one tube, and have experienced the maximum deviation at a flint-glass prism fixed in the angular point, pass out again through a fine slit in a diaphragm, placed before the end of the second tube. The rays at entering also are made to pass through a fine slit, on which they are concentrated by a cylindrical lens. They pass then, before they fall on the prism, through a convex lens, which is placed at the distance of its focal length from the slit, so that the rays are parallel when they reach the prism. The slit through which the rays pass out is moveable by means of a micrometer screw, and by the application of sunlight, the positions can be marked on the micrometer head in which light of the refrangibility of the seven Fraunhofer's lines passes through the slit; afterwards, the use of sunlight may be replaced by artificial light. Dutirou remarks that this may be advantageous, especially in measuring the refracting power of fluids, since in this case the sun's rays cause disturbance by changing the temperature. He farther remarks that the instrument may be yet improved by using a cylindrical convex lens, instead of a spherical one, to render the rays parallel; and, instead of the prism of common flint-glass, a similar one of borosilicate of lead. At the conclusion of his memoir, Dutirou gives a table, in which the ratios of the coloured spaces between Fraunhofer's lines, in the spectra of flint-glass and crown-glass, are compared together. It is easy to deduce these numbers from the coefficients of refraction, which were communicated in last year's Report(1).

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Arago(1), referring to the researches previously begun by him, and not completed on account of the weakness of his sight, draws attention to the fact that the change of refractive power of water, between 0° and $+10^{\circ}$, can be found with greater accuracy than by the prism by the interference of two rays, which have passed through columns of water of equal length, but different temperatures, and gives the arrangement of the apparatus required for the purpose.

Stokes(2) draws attention to the fact, that when the coefficient of refraction is determined by the displacement of the fringes of interference the result obtained is too great, because, on account of the greater breadth of the fringes for the less refrangible rays, the centre appears somewhat more displaced than is actually the case.

Ratios of the Refrangibilities of Fluids.—Powell(3) has, by a method previously described, and applied(4), determined the coefficients of refraction for some fluids, the results of which are as follows:

	Temp.	B	C	D	E	F	G	H
Huile d'Aspic	22°	1.4732	1.4746	1.4783	1.4829	1.4868	1.4944	1.5009
Oil of sandal-wood	20°	1.5034	1.5058	1.5091	1.5117	1.5151	1.5231	1.5398 ?
Oil of lavender.	20°	1.4641	1.4658	1.4660	1.4728	1.4760	1.4837	1.4930 ?
Benzol	18°	1.4895	1.4961	1.4978	1.5041	1.5093	1.5206	1.5310

Through a prism of chromate of lead, Fraunhofer's lines could not be recognized, and the blue and violet part of the spectrum was extinguished. The following ratios of refraction are only approximately determined for a prism with a refracting angle of about 14° , whose refracting edge was perpendicular to the axis of the crystal.

	First spectrum.	Second spectrum.
Line B about	2.53	2.84
" D "	2.55	3.00 ?
" E "	2.70	3.10

Delffs(5) has measured the indices of refraction of the following ethers:

Formiate of oxide of ethyl	$C_6H_6O_4$	1.3570
Acetate of oxide of methyl	$C_6H_6O_4$	1.3576
Acetate of oxide of ethyl	$C_8H_8O_4$	1.3672
Butyrate of oxide of ethyl	$C_{12}H_{12}O_4$	1.3778
Valerate of oxide of ethyl	$C_{14}H_{14}O_4$	1.3904
Acetate of oxide of amyl	$C_{11}H_{14}O_4$	1.3904

and concluded from them: 1. That the indices of refraction of the compound ethers increase with the atomic weights; 2. That the isomeric ethers have equal indices of refraction.—Since the deter-

(1) Compt. Rend. XXXI, 149; Instit. 1850, 249.

(2) Instit. 1850, 320; Sill. Am. J. [2] X, 392.

(3) Instit. 1850, 324; Sill. Am. J. [2] X, 392.

(4) Pogg. Ann. LXIX, 110.

(5) Pogg. Ann. LXXXI, 470.

minations are so made that, as Delffs himself says, they pretend only to approximate accuracy, it is especially necessary to ascertain and communicate the degree of approximation, that we may be in a condition to judge how far the preceding numbers actually justify the conclusion drawn from them.—Besides, Deville and Cahours(1) have made much more comprehensive determinations, unfortunately not by more accurate methods, and have arrived at conclusions similar to those of Delffs.

Ratios of
the refran-
gibilities
of fluids.

Chromatic Dispersion.—Stampfer(2) has attempted to determine the dispersive power of the atmosphere, by observing the sun near the horizon. The elevation of the telescope was continually altered by equal parts, and the contact of the sun with the horizontal wire observed with a red and blue dark glass alternately, and from the intervals of time the dispersive power was deduced. They gave for the two coloured glasses 0·01925, while the same interval of colour in crown-glass was 0·0241, and in water 0·0258. The dispersive power of the atmosphere is, therefore, $\frac{3}{4}$ that of water.

Total Reflection of Light.—The difference of phase Δ which the two components vibrating in and perpendicular to the plane of incidence acquire by total reflection, is expressed as follows by Fresnel's formulæ:

$$\tan \frac{\Delta}{2} = \cos i \frac{\sqrt{\sin (i-J) \sin (i+J)}}{\sin^2 J},$$

where J is the angle of incidence, at which total reflection commences.

Cauchy, on the contrary, from his formulæ for the reflection and refraction of light, which have been already experimentally confirmed by Jamin, has obtained the following expression for the case of total reflection,

$$\tan \frac{\Delta}{2} = \cos i \left\{ \epsilon + \frac{\sqrt{\sin (i-J) \sin (i+J)}}{\sin^2 J} \right\};$$

in which ϵ is the quantity called by Jamin(3) the coefficient of ellipticity. In order to test by experiment this consequence of theory, Jamin(4) has, by means of the compensator(5), measured the difference of phase which the two principal components of a ray, polarized with an azimuth of 45° , acquire by total reflection at the hypotenuse of a right-angled prism of plate-glass.—He convinced himself that a mass of perfectly pure internal structure must be used, in order that the

(1) Compt. Rend. X, 867; Pogg. Ann. LI, 427 and 433; LVII, 267.

(2) Wien. Acad. Ber. January, 1850, 34.

(3) Annual Report for 1849, III, 72.

(4) Ann. Ch. Phys. [3] XXX, 257; Compt. Rend. XXXI, 1; Instit. 1850, 209; Pogg. Ann. LXXXII, 279.

(5) Annual Report for 1849, III, 72.

Total
reflection
of light.

results may not be disturbed by irregular influences. But also with this precaution a source of error still remains behind, inasmuch as the superficial layers being altered by polishing, impart a difference of phase to the two principal components at the very entrance and emergence of the ray. Jamin, with his peculiar dexterity, was able to eliminate this source of error, by cutting the prism which he was going to use perpendicularly to its edge into three equal prisms, two of which he cemented together by their hypotenusal surfaces, with a substance (cassia and turpentine) whose coefficient of refraction was equal to that of glass. At the parallelopiped thus formed the ray underwent at the same angle of incidence two refractions, at the prism two exactly equal refractions and total reflection; by comparing the difference of phase and intensity in the two cases, the influence which the total reflection itself exercised on these two elements could be easily calculated. Jamin found, moreover, that when a glass prism is used whose coefficient of refraction $n=1.545$, the difference of the results of observation from the values calculated according to Fresnel, on account of the smallness of ϵ , lie within the limits of error. Jamin could not obtain a sufficiently homogeneous piece of a substance of high refrangibility, in which the difference must have made itself more manifest.

The Solar Spectrum.—Brewster(1) has examined the solar spectrum afresh, in regard to the dark spaces and black lines which it contains. Having shut off all light of greater refrangibility than the line *A* in the red, covered the interior of the telescope with black velvet, and cleared his eye as much as possible from the thick fluid which flows over the cornea, he perceived a part of the red spectrum of less refrangibility than the line *A*, which had never previously been perceived by any one. In the space between the lines *A* and *B*, in which Fraunhofer had distinguished 8 black lines, Brewster observed far more. For the detailed description of the two coloured spaces in question, we refer to Brewster's communication itself. As a good means of bringing out dark lines, which are otherwise difficult to distinguish, Brewster recommends the use of a cylindrical lens of small focal length, whose axis is placed at right angles to the lines, so that the lines, being almost reduced to points, the differences between the bright and the dark stand out more decidedly.—Brewster remarks farther, that all the black spaces by no means appear as sharply defined lines, as Fraunhofer represented them; but show themselves for the most part only as weaker or stronger, and gradually disappearing shadows, which, with still better means, might perhaps be resolved into a mass of fine black lines.. That the altitude of the sun exercises a decided influence on

(1) Compt. Rend. XXX, 578; Instit. 1850, 171; Pogg. Ann. LXXXI, 471.

the intensity of the light in these spaces, which clearly proves the influence of the atmosphere. The lines *D*, *m*, *C*, *B*, *a*, *A* and *M* changed, in certain states of the atmosphere, into broad black bands, and a certain place in the brightest part of the spectrum became entirely dark at the instant when the sun set with a red colour.—Finally, Brewster has found that, in like manner as Fraunhofer observed in the spectrum of artificial white light two bright streaks in the position of the dark line *D* of the solar spectrum, other artificial flames, as that of nitre burned upon charcoal, or of nitrate of strontia in alcohol, show bright streaks in the position of certain dark lines of the solar spectrum.

The solar spectrum.

Natural Colours.—J. Müller(1) of Freiburg, has, with reference to Brücke's definition of brown(2), communicated the analyses of the spectra of some brown fluids, with remarks thereupon, which are to be considered as a continuation of his memoir(3) on the natural colours.—The colours of the brown fluids which were examined have, it is true, this in common with the brown of the first order, which attracted Brücke's attention, that red, orange and yellow form the principal constituents; but while in the colours produced by interference no one of the prismatic colours is altogether wanting, the brown fluids absorb violet and indigo entirely, and blue almost entirely; and when they are so far diluted as to transmit the last-mentioned colours, the fluids appear more yellow than brown.—Altogether, the explanation of natural colours by interference is not sufficient without something more, inasmuch as concentrated coloured solutions generally absorb almost the whole spectrum, and only leave remaining extremely limited bright portions, these often of nearly undiminished brightness, and at other times crossed with sharply-defined black bands; while the colours of interference (for instance, those of thin plates of gypsum) limit the bright parts of the spectrum in a less degree, and show more gradual transition. Müller is of opinion that the analogy may probably be represented by the combination of several interference colours—as, for instance, by three Nicol's prisms behind one another, each consecutive two crossing one another, and between each two a thin plate of gypsum.

Maumené(4) makes a communication to the effect that the composition of complementary colours to white can be shown very beautifully, by means of a rose-coloured solution of cobalt and a green solution of nickel.

(1) Pogg. Ann. LXXIX, 344.

(2) Compare Annual Report for 1847 and 1848, I, 156.

(3) Compare Annual Report for 1847 and 1848, I, 154.

(4) Compt. Rend. XXX, 209; Instit. 1859, 66.

Classifica-
tion of
colours.

Classification of Colours.—Doppler(1) has made a new proposition for the systematic classification of colours(2), which, resting on clear and right principles, he believes will conduct to important consequences. On a line which makes equal angles with three rectangular co-ordinate axes, Doppler conceives a unit of intensity of *white* (grey) light set off; fractions of this line indicate darker shades, from grey to black, to which latter the origin of co-ordinates itself corresponds. Multiples of that line correspond to still greater intensities of white light. The projections of that unit on the three axes give the units of *red*, *yellow* and *blue* light. According to this, $w = \sqrt{r^2 + y^2 + b^2}$; that is, the intensity of the white combination would not be the sum of the intensities of the component coloured rays, but the composition would take place according to the law of the parallelogram of forces, an assumption which will find admission nowhere unless it be based incontrovertibly on experimental proof.—The line which bisects the angle between the two axes in the co-ordinate plane (r, y) corresponds to orange, the corresponding line in the plane (y, b) to green, and that in the plane (r, b) to violet. A sphere of radius unity contains on the surface of the octant (r, y, b) the three fundamental colours in the corners, the binary compounds in the varying ratio of their constituent parts along the three sides, so that *orange*, *green* and *violet* fall in the middle of the sides. The ternary compounds on the surface of the octant approximate still more closely to grey, which falls in the middle of the surface of the octant. The greater the intensity of the light altogether, so much the more the shades come out; the darker the grey, so much the more the differences disappear, till they at last disappear completely in black.

Angle of the Optic Axes of Biaxial Crystals.—The angle of the optic axes in arragonite and topaz, as it has been calculated by the formulæ of the undulatory theory from the coefficients of refraction of those rays which set the ether in motion in the direction of the three axes of elasticity measured so carefully by Rudberg(3), differs very notably from the values which Rudberg found for arragonite, and Brewster and Biot for topaz, by immediate measurements. If, for comparison, the angle is taken which the rays which have passed along the optic axes make with one another after their emergence from the crystal, we have for the line *D* of the spectrum :

	By calculation.	By observation.
Arragonite	33° 17' 46"	32° Rudberg.
		120° 14' 20" Brewster.
Topaz . .	99° 52' 46"	118° 47' 44" Biot.

(1) Zwei weitere Abhandlungen aus dem Gebiete der Optik, von Chr. Doppler. Prague, 1848.

(2) Compare Forbes' Classification in Annual Report for 1849, III, 79.

(3) Pogg. Ann. XVII, 1.

Angle of
the optic
axes of
biaxial
crystals.

Wilde(1) wished to establish a greater harmony between calculation and observation, as follows: he did not, like Rudberg, calculate the angle between those directions in which the ordinary and extraordinary rays are propagated with equal velocities (the angle of the apparent optic axes), but rather the angle between the directions in which plane waves are propagated in the crystal without being decomposed or altered in their state of polarization (the angle between the true optic axes). But without mentioning that an assimilating of the results of calculation and observation so obtained is only insignificant in the highest degree, it is, in fact, the first angle which is here under consideration. Zamminer(2) has remarked on this subject, that as regards the employment of the correct formulæ, Wilde and not Rudberg has fallen into error. Zamminer farther proves that the calculation of the angle of the axes from the coefficients of refraction by the formulæ

$$\sin^2 \alpha = \frac{n''^2 - n'^2}{n'^2 - n^2} \text{ for negative crystals, and}$$

$$\sin^2 \alpha = \frac{n'^2 - n^2}{n''^2 - n^2} \text{ for positive crystals,}$$

is necessarily uncertain, because only the differences of the coefficients of refraction are employed, and therefore errors, such as can readily arise from the incorrect adjustment of the surfaces of the prism to the axes of the crystal, must operate very unfavourably on the result. The difference between calculation and observation in topaz is not too great to be explained by such a circumstance.

Distinguishing of Optically Positive, and Negative Crystals.—

Moigno and Soleil(3) communicate a new characteristic for distinguishing optically positive and negative crystals. They start from Brewster's discovery that a pressure exerted perpendicularly to the axis of an optically uniaxial crystal, converts it into a biaxial crystal, so that the system of concentric rings of the uniaxial crystal may be seen to pass into the system with two foci and the dark brushes, belonging to it, between the tourmaline plates. Moigno and Soleil found, that in positive crystals—as, for instance, in rock crystal—the system of rings separated in the direction of the pressure, while in negative crystals, as in beryll and tourmaline, the separation took place in a plane perpendicular to the direction of the pressure. Moigno and Soleil commence with an enumeration of the remaining distinguishing characteristics as they were found out by Mitscherlich, Babinet, Sénarmont, Plücker and Brewster. The difference assumed by Plücker depending on magnetic properties is, however, lately found not to stand the test (compare the section

(1) Pogg. Ann. LXXX, 225.

(2) Ann. Ch. Pharm. LXXVI, 121.

(3) Compt. Rend. XXX, 361; Instit. 1850, 99.

Distin-
guishing of
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and nega-
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tals.

Magnetism in this Report). In the introduction of the memoir by Moigno and Soleil it is said: "That the positive or attracting crystals are those in which the coefficient of refraction of the extraordinary ray is smaller than that of the ordinary ray. The extraordinary ray recedes less from the axis, it moves less quickly than the ordinary ray." We must consider this an error of the editor, although the same contradiction occurs again in the characteristic of the negative crystals. In positive crystals the coefficient of refraction of the extraordinary ray is the greater, just because this ray moves less quickly.

State of Polarization of Two Rays in Quartz.—Airy first brought to a common point of view the phenomena which plates of rock crystal cut perpendicular and parallel to the axis, exhibit in polarized light, by supposing that the two circularly polarized rays which pass through the rock crystal in the direction of its axis with unequal velocities, pass gradually through all intermediate states of elliptic polarization into the two plane polarized rays which a plate of quartz cut parallel to its axis exhibits, like any other doubly-refracting plate.—It still remained to measure the ratio of the axes of the elliptic vibration in the two rays, as well as the difference of phase which they acquired at different inclinations to the optic axis of the rock crystal. This work has been accomplished by Jamin(1). He made a ray from a lamp containing alcohol mixed with salt (after being polarized by passing through a Nicol's prism) fall at different angles of incidence on a plate of quartz cut perpendicular to its axis, so that the vibrations were perpendicular to the plane of incidence. By this, on emergence from the plate, two rays were obtained vibrating in the principal planes, of a certain difference of phase, which was then destroyed again by means of Babinet's compensator(2). Jamin each time gave the compensator a position beforehand which corresponded to a determinate difference of phase, and then inclined the plate of quartz. The angle of incidence at which the compensation for the difference of phase took place was then read off, as well as the azimuth of the resulting plane polarization; the tangent of this gave the ratio of the amplitudes of the two components.

In order, on the other hand, to express what takes place in the plate of quartz conformably to the hypothesis of Airy, let the direction of vibration in the plane of incidence be denoted by x , that perpendicular to the plane of incidence by y and first let a ray vibrating in the direction y , fall on the plate. The vibration $y = A \sin \xi$ is resolved into two elliptic vibrations of opposite directions, the ratios of whose axes are respectively k and k' , viz.:

$$\begin{aligned} x &= \cos \xi & x' &= -\cos \xi \\ y &= k \sin \xi & y' &= k' \sin \xi \end{aligned}$$

(1) Ann. Ch. Phys. [3] XXX, 55; Compt. Rend. XXX, 99; Instit. 1850, 41, 51; Report on it Compt. Rend. XXXI, 112.

(2) Annual Report for 1849, III, 72.

where $k + k' = A$. After the two rays have traversed the crystal, they have acquired a difference of phase δ , and their equations are

$$\begin{aligned} x &= \cos \xi & x' &= -\cos (\xi + \delta) \\ y &= k \sin \xi & y' &= k' \sin (\xi + \delta) \end{aligned}$$

State of polarisation of two rays in quartz.

and if

$$X = x + x' = A \sin (\xi + \phi); \quad Y = y + y' = B \sin (\xi + \phi')$$

are the components of the emergent ray, we have :

$$\tan (\phi' - \phi) = \frac{k' - k}{k' + k} \cdot \tan \frac{\delta}{2} = n \quad (1)$$

$$\text{and } \frac{B^2}{A^2} = \frac{(k + k')^2}{4 \sin^2 \frac{\delta}{2}} - kk' = m^2 = \tan^2 a \quad (2)$$

$(\phi' - \phi)$ and a are the magnitudes which are immediately observed, but they would not suffice for the calculation of the three unknown quantities δ , k and k' , unless a relation between those magnitudes were discovered by a farther consideration.—If, however, the same resolution as above is gone through with a ray which vibrates parallel to the axis of x , we obtain by combination with equation (2) $kk' = mm'$, and since observation shows that for the same angle of incidence $m = \frac{1}{m'}$, we have $k' = \frac{1}{k}$, and therefore from (1) and (2)

$$\tan^2 \frac{\delta}{2} = n^2 + \frac{1 + n^2}{m^2} \quad (3)$$

$$\text{and } k = + \left(\frac{mn}{\sqrt{1 + n^2}} \pm \sqrt{1 + \frac{m^2 n^2}{1 + n^2}} \right) \quad (4).$$

We give in the following table, out of a very extended series of observations, results which are reduced to a thickness of the plate of 1^{mm} , and compared with the results obtained from Cauchy's formulæ:

Angle of Incidence.	Ratio of Axes = k :		Difference of path of the two rays :	
	Observed.	Calculated.	Observed.	Calculated.
1° 5'	0.972	0.980	0.123	0.120
5° 15'	0.639	0.661	0.133	0.132
10° 39'	0.285	0.245	0.261	0.257
14° 58'	0.161	0.129	0.474	0.461
20° 48'	0.070	0.067	0.877	0.850
23° 15'			1.066	1.100

Airy's hypothesis, according to which, in place of the spherical and spheroidal surfaces touching at the extremities of the axis of the latter, two spheroids *not* in contact were to be substituted, Jamin found not to be confirmed by his measurements. On the contrary,

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the formulæ newly developed by Cauchy apply excellently, namely for small angles of incidence :

$$\frac{d^2 - d_0^2 \cos^4 r}{\sin^4 r} = p^2; \quad p = \frac{n}{n'} \cdot \frac{e}{l} (n' - n);$$

$$k = \pm (h \pm \sqrt{1 + h^2}); \quad h = \frac{p}{d_0} \tan^2 r.$$

Here d is the difference of path of the two rays for any small angle of incidence, d_0 the difference of path for direct incidence = 0.12.1 according to Jamin; r the angle of refraction, n and n' the coefficient of refraction of the two rays which are propagated perpendicularly to the axis, e the thickness of the plate, l the length of a wave = 0.000561 millimetres, in the preceding case. Jamin found $n' - n = 0.00905$ and thence $p = 16.034$.—As may be perceived from the preceding table, at an inclination of 20° to the axis of the rock crystal, the minor axis of the ellipse is already sensibly zero, or the polarization of the two rays is at this angle of incidence already become plane, the difference of path increases to a greater and greater amount the more the angle of incidence increases.—For the rest, Jamin obtained a still better accordance between observation and calculation, when, without using the compensator, he determined the angles of incidence at which bright and dark lines passed through the field of view, when the plate of rock crystal was more and more inclined between two Nicol's prisms. For the dark lines $\delta = 2n\pi$, for the bright ones $\delta = (2n + 1)\pi$ and $\frac{1}{k} - k = \pm 2m$.

Double Refraction of Water at Different Temperatures.—Biot(1) had already previously occupied himself with the question whether water between the point of maximum contraction and the freezing-point, did not exert an influence on polarized light. Although he previously always obtained negative results, he yet had an inducement to return again to this question. He allowed pure water to stand through the whole winter in a silver tube of 502^{mm} in length, and 37^{mm} in diameter, and observed daily, by means of one of Soleil's double plates, whether a polarizing action was not going on. The apparatus was so arranged that the water could expand and contract freely, and its temperature be measured most accurately. From November 23rd, 1849, to February 1st, 1850, the temperature fluctuated between $+6^\circ.3$ and $-2^\circ.2$. At no time was there any perceptible action on the polarized light.

Splitgerber(2) calls attention repeatedly to a phenomenon of polarization already previously mentioned(3), which appears in the

(1) Compt. Rend. XXX, 281; Pogg. Ann. LXXX, 570; Instit. 1850, 81; Arch. Ph. Nat. XIV, 45.

(2) Pogg. Ann. LXXIX, 297.

(3) Pogg. Ann. LXXVI, 566.

devitrification of good, pure glass, and is produced by the formation of spherical white specks in the mass of the glass, inasmuch as these, in their endeavours to separate, produce a state of constraint in the whole surface of the glass.

Pleochroism and lustre.

Pleochroism and Lustre.—Rammelsberg(1) in a memoir on the composition of tourmaline, gives a review of the optical properties of the five different groups in which he classifies the varieties of this mineral, especially of the dichroism perceivable with the dichroscopic lens. The latter is only found in those tourmalines which contain iron or manganese, or both, in different states of oxydation, while such crystals as are only coloured with those metals in one state of oxydation appear single coloured.

Haidinger(2) gives a description of the colours of the surface and interior of Andersonite (a combination of iodine and codeine), into the details of which we do not enter. He considers the phenomena of these surface colours as a new confirmation of the law put forward by him(3) according to which the direction of polarization of the polarized surface colour coincides with that of the more absorbed ray in double refracting crystals.

Haidinger(4) has confirmed the phenomena of lustre of surface, observed by Brewster in chrysammate of potassa; but has besides remarked that the laminae of crystal pressed with a knife upon the support, show different colours according to the azimuth. At direct incidence the eye sees a metallic colour between a bronze-yellow and steel-grey, the dichroscopic lens gives *R* a brass-yellow, *O*, steel-grey. In the longitudinal position (with reference to the streak-) *O* passes in an inclined position through steel-grey and violet into white; *E* passes through gold-yellow, brass-yellow, grass-green, emerald-green, verdigris-green, to a dark indigo-blue. In the transverse position *O* is brass-yellow, *E* passes from a violet-steel-grey to indigo-blue and red, without acquiring a trace of green. Similar changes of the shade of colour in different azimuths Haidinger found in platino-cyanide of potassium, while platino-cyanide of magnesium, aloetinate of potassa, murexide and hydrokinone were the same in all azimuths, when they were rubbed off in small scales.

The pleochroism of ferricyanide of potassium is characterized by Schabus(5) in the following manner. The colour of the base (*A*) is light hyacinth-red, brightest shade; that of the surface parallel to the greater diagonal (*B*) light hyacinth-red, middle shade; the colour of the surface parallel to the shorter diagonal (*C*) dark hyacinth-red.

(1) Pogg. Ann. LXXXI, 36; Berl Acad. Ber. 1850, 278.

(2) Pogg. Ann. LXXX, 553; Edinb. New Phil. Journ. L, 122.

(3) Annual Report for 1849, III, 82.

(4) Pogg. Ann. LXXXI, 572.

(5) Wien. Acad. Ber. May, 1850, 592.

Rotation
of the
plane of
polariza-
tion.

inclined to carmine-red, darkest shade. After the resolution through the dichroscopic lens there results :

- a. Colour of the axis, dark hyacinth-red, inclined to carmine-red ;
- b. " " long diagonal, dark hyacinth-red, middle shade ;
- c. " " short diagonal, very light hyacinth-red.

Rotation of the Plane of Polarization.—Pasteur(1) has made some new contributions to the discussion of the question whether the property of crystallizing in incongruous hemihedrons, is found uniformly conjoined with the optical rotating power in the same substance, or not.—He found that asparagin, which shows a hemihedral conformation of that kind, dissolved in water or alkali, turns the plane of polarization to the left, dissolved in mineral acid on the contrary turns it to the right. The optical property of aspartic acid he found very much like that of asparagin.—The opinion of many chemists that asparagin is to be considered as an amide of malic acid, induced Pasteur to submit malic acid and its salts to the optical test. He found great similarity in the optical rotatory power between malic acid and the two oppositely rotating tartaric acids(2). Since moreover malic acid occurs frequently in the fruit with right-hand rotating tartaric acid, Pasteur believes he may assume that one of these acids may pass into the other, and that perhaps also a second malic acid exists, corresponding to the left-hand rotating tartaric acid.—From the solution of formate of strontia, two incongruous hemihedrons crystallize. If these are separated, and each kind of crystals dissolved separately, nevertheless no influence is exercised on polarized light. Pasteur remarks that it is conceivable that the hemihedral conformation in this salt rests not on the peculiar grouping of the chemical molecules, but only on the arrangement of the physical molecules in the act of crystallization, so that the solutions exhibit no peculiarity corresponding to hemihedral forms.—With reference to the form of crystallization of the several combinations, compare the Chemical part of this Report. —In the report presented to the Academy Biot(3) states as a general result of Pasteur's work, the law that all substances which possess the optical rotating power and crystallize in hemihedrons, always possess the incongruous hemihedral conformation. The converse of this law, on the contrary, does not generally hold, as formate of strontia and sulphate of magnesia prove.

Circular Polarization of Isomorphous Bodies.—Pasteur(4) has concluded, from observations on neutral and bitartrate of potassa

(1) Compt. Rend. XXXI, 480; Instit. 1850, 313; Arch. Ph. Nat. XV, 238; Pogg. Ann. LXXXII, 144; more in detail, Ann. Ch. Phys. [3] XXXI, 67; J. Pr. Chem. LII, 413.

(2) He previously denominated these as oppositely rotating racemic acids. See Annual Report for 1847 and 1848, I, 22; for 1849, III, 87, 209.

(3) Compt. Rend. XXXI, 601; Instit. 1850, 355.

(4) Inst. 1850, 339.

and ammonia which are isomorphous, that when quantities of isomorphous substances corresponding to the equivalents are dissolved in equal quantities of water, these solutions rotate the plane of polarization equally. Pasteur is of opinion that this law may furnish a general criterion of isomorphism even for such substances as exercise no influence on the plane of polarization. In order, for instance, to recognize the isomorphism of hydrochloric acid and hydriodic acid, it is only necessary to combine equivalent quantities with an optically active base (for instance, morphine), and submit the combination to the optical test.

Circular polarization of isomorphous bodies.

Laws of Circular Polarization.—We do not here enter farther on Biot's memoir(1), on the rotating power of solid bodies, the principal contents of which we have already communicated in last year's Report(2) from an abstract, ~~in~~ order to gain space for the discussion of some later memoirs of the same physicist. The reading of the memoir alluded to will, however, be useful, inasmuch as therein is laid down a clear exposition of the theoretical points of view of the subject in question, already contained in certain papers of Biot(3).

Starting from the law that, if an optically active body, mixed with an inactive one, rotates the plane of polarization in a greater or less degree than in a pure state, this may be considered as a proof that a chemical action has taken place on the optically active molecule, which yet has not been powerful enough to resolve the complex molecule, or transform it permanently,—Biot(4) investigates optically, the changes which tartaric acid experiences from heating. This change is conceived differently by Fremy than by Laurent and Gerhardt(5), and Biot is of opinion that the optical test affords a strong proof that the conception of the latter chemists is right.—Biot comprehends the results belonging hereto in the two following laws.

1. In all phases through which the acid passes before its last anhydrous condition, it exerts *instantly*, as soon as the solid mass is again dissolved in cold water, a rotating power on the polarized light, which is fully equal to that of the crystallized acid.—The particles of the altered acid combine with the whole mass of the water with which they are mixed, as instantaneously as occurs with the crystallized acid. The absolute rotating power, as well as the laws of dispersion, as far as they can be definitely decided, are the same for both acids.

(1) Ann. Ch. Phys. [3] XXVIII, 215, 351.

(2) Annual Report for 1849, III, 87.

(3) Annual Report for 1847 and 1848, I, 150.

(4) Ann. Ch. Phys. [3] XXIX, 35, 341; Compt. Rend. XXX, 721; Instit. 1850, 195.

(5) See Annual Report for 1847 and 1848, I, 389; comp. also the article "Tartaric Acid," in the Chemical part of this Report.

Laws of
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polariza-
tion.

2. If boracic acid is added to the fresh solution of changed tartaric acid, the similarity in the optical properties no longer exists. The laws of dispersion, it is true, are altered exactly as by the addition of boracic acid to crystallized tartaric acid; but the absolute rotating power of the solution is less, the more water the acid had previously lost by heating. But meta-tartaric acid also (the first stage of change by heat, without loss of water) shows, under these circumstances, a manifestly smaller rotating power. At ordinary temperatures, the optical power of this solution increases from day to day, till it has reached the value which belongs to the crystallized acid. By boiling, the increase of the optical power is accelerated, yet its maximum is only reached after long-continued heating.

The idea naturally suggests itself to explain the gradual increase of optical power, by assuming a continually increasing saturating capacity for the modified tartaric acid, and hence a chemical influence on continually increasing quantities of boracic acid. But Biot considers this assumption inadmissible, because each fresh addition of boracic acid effects each time immediately an increase of the optical power. He believes it may be concluded from this, that the particles of the modified tartaric acid enter immediately into chemical combination with all the boracic acid mixed with it, as well as with the added water; and that only in proportion as the tartaric acid returns again to its former crystallizable state, the intimacy of its combination with the boracic acid, and therewith its optical rotating power increases.

If soda is added to equal quantities of crystallized and fused tartaric acid in sufficient quantity to neutralize it, the latter acid is *immediately* converted to the condition of the former; it shows immediately, as well in the presence of water as of boracic acid, the same optical power as the former.—Tartaric acid and boracic acid act also chemically on one another, when both are combined with soda. By the mixture of tartrate of soda with borax, the optical power of the former salt was immediately increased in the ratio of 42° to 51° .

In several earlier memoirs, Biot has proved that the manner in which the specific rotating power of tartaric acid is increased by the addition of water or of boracic acid, may be expressed by equations of the form: $(\alpha) = A + Be$ and $(\alpha) = A + B'\beta$, in which (α) represents the specific rotating power, e and β the proportions of water and boracic acid in a unit of weight of the mixture; A changes(1) only with the temperature, and B and B' are constants.

(1) The values of A at temperatures between $+6^\circ$ and $+26^\circ$, are given in Biot's investigation quoted above (Ann. Ch. Phys. [3] XXVIII, 226). They are, for instance,

+ 6°	— $2^\circ 23873$
+ 22°	— $0^\circ 06753$
+ 23°	+ $0^\circ 03309$
+ 26°	+ $0^\circ 31739$

In a more recent paper, Biot(1) proposed to himself the problem, to represent in the most general manner the optical properties of the ternary mixture of tartaric acid, water, and boracic acid. He selected for this purpose the following mode of expression: Let the mixture consist of ϵ parts of tartaric acid, e parts of water, and β parts of boracic acid, so that $\epsilon + e + \beta = 1$. Let ρ represent the quotient $\frac{\epsilon}{\beta}$, then the optical power of the mixtures for equal values of ρ , that is, for quantities of the two acids in a constant ratio, but for varying proportions of water, may be always represented by an equation of the form: $(\alpha) = a + b e$; a and b are functions of ρ , and it turns out that, while for large values of ρ , and therefore for a proportionately small addition of boracic acid, the admixture of water increases the optical power, therefore b is positive; for mixtures, on the contrary, containing more boracic acid, the addition of water rather exercises a weakening influence on the optical properties, therefore b is negative. Conceive the values of e to be laid down as abscissæ, and of (α) as ordinates, the increase or diminution of optical power will be represented by an ascending or descending straight line, and b expresses then the tangent of the angle which the straight line makes with the axis of abscissæ. In the following table, which contains values of a and b ascertained by observation, corresponding to different values of ρ , this angle is represented by J .

ρ	a	b	J
100	+ 5 ⁰ .0531	+ 9 ⁰ .1479	+ 83 ⁰ 46'
22.917	+ 11 ⁰ .6345	+ 9 ⁰ .1866	+ 83 ⁰ 47'
15.039	+ 19 ⁰ .9238	+ 3 ⁰ .3798	+ 73 ⁰ 31'
10.208	+ 28 ⁰ .1194	— 1 ⁰ .5777	— 57 ⁰ 38'
3.043	+ 71 ⁰ .0096	— 3 ⁰ .7396	— 75 ⁰ 2'
2.476	+ 79 ⁰ .9955	— 4 ⁰ .6354	— 77 ⁰ 50'
2.035	+ 88 ⁰ .5661	— 5 ⁰ .5212	— 79 ⁰ 44'
1.998	+ 89 ⁰ .3540	— 5 ⁰ .6070	— 79 ⁰ 53'

It is clear that between $\rho=10$ and $\rho=15$, a value must exist for which $b=0$. Biot found that this is very nearly the case for $\rho=11\frac{1}{2}$. In a mixture containing the acids in this proportion, the specific rotating power remains the same for any dilution with water, and indeed, as Biot assumes, on this account, because the addition of water loosens the connection of the molecules of the tartaric acid and boracic acid, and this lessens the optical power just as much as it would be increased by the accession of the water to the molecules of tartaric acid. If $\rho > 11\frac{1}{2}$, the addition of water

(1) Ann. Ch. Phys. [3] XXIX, 430; Compt. Rend. XXXI, 101; Ann. Ch. Pharm. LXXVI, 189 (in abstr.)

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increases the strength; on the contrary, if $\rho < 11\frac{1}{2}$, the rotating power is more weakened by the loosening the connection of the two acids by the addition of water, than the water is able of itself to strengthen it.

Influence of Acids on Cane-sugar and Molecular Rotating Power.—Wilhelmy(1) has, by means of an Amici's polarizing apparatus and a Soleil's double plate, investigated the action of acids on cane-sugar. He has, in doing so, allowed mathematical investigation to go hand in hand with the observations. Conformably to the limits assigned to this Report, we communicate here principally the process and the results of the experimental investigation.—Since in almost all the cases in question the temperature exercised a very considerable influence, it was necessary that the glass tubes, which contained the mixtures of the solution of sugar, with the acids made use of (sulphuric acid, hydrochloric acid, nitric acid, and phosphoric acid), should be surrounded with an apparatus which allowed the temperature to be kept constant, and observed accurately.

Wilhelmy found it necessary in the first place to determine the coefficient of rotation, so-called by Biot, that is the number μ which expresses how much a quantity of sugar, which caused a right-handed rotation of 1° , rotates to the left hand after reversal with one or the other acid. As the rotation of the changed sugar, considerably decreased with a rise of temperature, Wilhelmy attempted next to ascertain the magnitude of this decrease. He brought into his polarizing apparatus sugar reversed by hydrochloric acid, in a silver tube 250^{mm} long, and 10^{mm} in diameter inside, which stood in a wooden box 57^{mm} wide, filled with hot water, and he observed in several series of experiments the increase of the rotating power, while the temperature gradually sank, or was reduced by the addition of ice-water and ice. The result is expressed by the following formula: $D' = D [1 - 0.012 (t' - t)]$, in which D and D' indicate two rotations corresponding to temperatures t and t' . The changes calculated by this agree very well with those which can be deduced from Clerget's table(2).—The absolute value of the coefficient of rotation, was

	Wilhelmy.	Biot.
For sulphuric acid . . .	$\mu = 0.425$	0.417
„ nitric acid . . .	$\mu = 0.399$	0.394
„ hydrochloric acid . .	$\mu = 0.386$	0.380

For phosphoric acid Wilhelmy assumed, for reasons which he did not explain farther, $\mu = 0.43$.—Now, if the original quantity of sugar Z_0 and the rotation D after the acid had acted during a time T were

(1) Pogg. Ann. LXXXI, 413, 499.

(2) Annual Report for 1849, III, 84.

measured, the quantity of sugar still remaining unchanged could be calculated by the formula: $Z = Z_0 - \frac{Z_0 - D}{1 + \mu}$ (1).

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After Wilhelmy had convinced himself that the final result of the change of the sugar is independent of the quantity of acid originally added, he based on it a mathematical investigation, which, as regards the progress of the change with the time, leads to the formula $Z = Z_0 e^{-msT}$, in which Z_0 is the original quantity of sugar, Z the quantity remaining after a time T , during which the acid acted, s the quantity of acid added, m a constant, and e the base of the Napierian logarithms. Since from this $msT = \log Z_0 - \log Z$, it appears that $\log \frac{Z_0}{Z}$ or (2) $\log (1 + \mu) - \log \left(\frac{D}{D_0} + \mu \right)$ must be proportional to the time T . This was, in fact, confirmed in a series of experiments continued through eleven hours, during which the rotation, which the solution of sugar gave, changed from $+46.75^\circ$ to -10° . If this be considered as settled, it follows that the value $m = \frac{\log Z_0 - \log Z}{sT}$ must remain constant as long as s and the temperature do not change. On the contrary, it appeared that $\frac{\log Z_0 - \log Z}{T} = ms$, does not remain proportional to s when the quantity of acid is varied, but increases more rapidly than this, so that consequently m must be dependent on s . Wilhelmy believes that he has found the right

expression for m in $m = \frac{n a^{\frac{s}{w}}}{w}$, where s is the quantity of acid, w the quantity of water added to it, a a constant, different for different acids, and n a quantity depending on the temperature.—From his experiments, Wilhelmy calculates

For hydrochloric acid	$\log a = 4.09170$
„ nitric acid	$\log a = 2.8222$
„ sulphuric acid	$\log a = 2.2243$
„ phosphoric acid	$\log a = 0.41551$

Farther, the following values were obtained for n :

- (1) This formula does not appear quite intelligible. We find $Z = Z_0 - Z_0 \frac{D_0 - D}{D_0 (1 + \mu)}$, in which expression D_0 represents the rotation in the commencement; or $\frac{Z}{Z_0} = \frac{\frac{D}{D_0} + \mu}{1 + \mu}$. Wilhelmy's numerical results agree, however, with those obtained by the latter formula.
- (2) The value of $\log \frac{Z_0}{Z}$ here given, is that which would be deduced from the formula given in the previous note.

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	Series I.		Series II.		Series III.		Series IV.	
	<i>t</i>	<i>n</i>	<i>t</i>	<i>n</i>	<i>t</i>	<i>n</i>	<i>t</i>	<i>n</i>
For hydrochloric acid	17°	2.118	17°	1.521	16°·5	1.681	16°·5	1.579
„ nitric acid . . .	16°	0.9905	16°	0.9905	18°·5	1.373		
„ sulphuric acid . .	17°	0.7764	18°	0.8508				
„ phosphoric acid .	19°·6	0.1752	19°·8	0.1710				

If, however, the values of *n* are calculated from experiments made at different temperatures by the formula:

$$\log Z_0 - \log Z = n a^{\frac{s}{w}} \cdot \frac{s T}{w},$$

it appears that for different acids the values of *n* change according to the same law with an increase of temperature, and that the parameters only of the curves which represent these changes are different. —Wilhelmy found the following expression for *n*, which represents the results of experiment with sufficient accuracy, while he at the same time allowed himself to be influenced by theoretical views, on which we do not enter any farther:

$$n = C (1 - \alpha t) \beta^t,$$

and he determined from three equations $C = 0.1136$; $\alpha = 0.0154709$;

$\beta = 1.186173$. Put then $\frac{s}{w} = q$, and we have from all that has preceded

the complete formula for calculating the quantity of sugar *Z* still remaining after the time *T*, when the original quantity *Z*₀ has been changed at temperature *t* by the quantity of acid *s* mixed with the quantity *w* of water:

$$Z = Z_0 \cdot e^{-C(1-\alpha t)\beta^t \cdot a^q \cdot q \cdot T}.$$

The above value of $C = 0.1136$ answers for hydrochloric acid, and we have

For nitric acid . . .	$C' = 0.60222$	<i>C</i>
„ sulphuric acid . .	$C' = 0.42169$	<i>C</i>
„ phosphoric acid . .	$C' = 0.072365$	<i>C</i>

Wilhelmy intimates at the conclusion of his paper, that it might perhaps be possible, out of the materials given by him, to draw conclusions on the law of decrease of the action between the molecules of acid and sugar with the increase of the distance. In a future investigation he expects to ascertain, whether the pressure of the atmosphere also exercises any influence on the chemical process which takes place between the acid and sugar, and which is established by optical properties.

In a second paper, Wilhelmy(1) proposed to himself the problem

to determine for a great number of substances the molecular rotating power, so named by him. Biot has, as is known, given the name of specific rotating power to the rotation which a lamina 1^{mm} thick, of a substance in the state of a hypothetical density 1 produces, and investigated it for various substances. Wilhelmy, on account of the molecular nature of the whole process, considered it more suitable to compare the rotations produced by quantities of the different substances proportional to their atomic weights, in equal weights of a dissolving medium, and for equal sections of the tubes. Where the proportions in which any substance dissolved, or the scarcity of it did not allow of the direct employment of quantities proportional to the atomic weights, a reduction was undertaken on the hypothesis, that the quantity of the dissolving medium has no influence on the molecular rotating power. Certainly for many substances—for instance, as Biot showed for tartaric acid—that hypothesis is not admissible. Wilhelmy, however, considered it applicable to the substances mentioned below. The deviations contained in the following table, found at a temperature of 15°, were obtained by the use of a glass tube, which, in a length of 150^{mm}, held 13·850 grammes of distilled water.

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Name of the Substance	Quantity by weight dissolved	Dissolving medium	Degree of rotation		Atomic weight (O = 100).	Molecular rotating power
			white light	red light		
Cane sugar	4309	Water.	+ 32 5	25	214 5	+ 100 white light.
Nicotine	1301	Alcohol.	16			
" with hydrochloric acid			+ 1 0	is		
Santonin	500	"	- 9	6 7	3005	- 332 3 white light
Hematoxylin	1849	"		13 5		
Jalapin	2000	"		7		
Camphor	6000	"	+ 31	22	963 8	+ 30 7 white light
Phloridzin	2377	"	- 11	8 7	2082 5	- 59 2 white light
Quinine	1782	"	- 24	20	2055 5	- 174 white light.
"	891	"	- 12 5	- 9 65		
" with nitric acid	"	"	- 17	.		- 241 4
" with phosphoric acid	"	"	- 15	.		- 213
Sulphate of quinine	1000	Water with sulph acid	- 24 5	- 16 7		
Valerate of quinine	"	Alcohol.	- 16	- 13		
Hydrochlorate of quinine	500	"	- 10			
Cinchonine	454	"	+ 12	.	1942	+ 315 8
" with oxalic acid	494	"	+ 12 5	.		+ 302
" " phosphoric acid	952	"	+ 23 5	.		+ 295
" " nitric acid	930	"	+ 20	.		+ 257
" " "	465	"	+ 10	.		
Quinoidine	374	"	+ 9 5	+ 8		
" with nitric acid	"	"	+ 9 75			
" " phosphoric acid	"	"	+ 10			
" " hydrochloric acid	"	"	+ 10			
" " sulphuric acid	"	"	+ 11 5			
Brucine	984	"	- 8	.	3448	- 172 5 white light
" with phosphoric acid	"	"	0	.		
Narcotine with sulphuric acid	936	Water	+ 5 5	.	4684	+ 169
Acetate of morphine	490	"	- 4			
Hydrochlorate of codeine	578	"	- 5			
Ethereal oil of cubebs	7460	Alcohol.	- 33 5			
" " valerian	7480	Ether	- 15 5			
Balsam of copaiva	7560	Ether with alcohol	- 11 5			

Apparatus
and
instru-
ments.

The molecular rotating power of cane-sugar is here taken = 100.— Besides this, Wilhelmy found that in a column 150^{mm} long of oil of amber, the white light deviated through -12° , castor oil $+6^{\circ}$, croton oil, the red light through $+8^{\circ}$, farther in a column 39^{mm} long for Balsam of copaiva the white light deviated through $-4^{\circ}5'$. Theine or caffeine showed no influence, even in a column 400^{mm} long.

Apparatus and Instruments.—Düroscq(1) has arranged for optical purposes an apparatus for showing a constant electric light, similar to the one invented by Foucault(2).

A. Roppe(3) describes an instrument which he calls an interference-scope, intended to render visible the figures produced by the interference of different system of waves. By a winch and wheel-work a rod which lies at the bottom of a cistern filled with water, is set in oscillation, and some wires attached to the rod excite, by means of their ends, which reach to the surface of the water, waves following one another very rapidly (100 to 200 in a second). If the surface is illuminated by sunlight, the caustics formed by the summits of the waves may be received on a screen of ground-glass placed at the bottom, and conveniently studied by means of a mirror inclined at an angle of 45° , which is placed below the tub.

Now details regarding the internal arrangement of reflecting-telescopes, for grinding, polishing, moving and mounting the speculum have been given by Nasmyth(4), J. Hippisley(5), and Lassell(6). Any(7) has given a report on the polishing and mounting of Lord Rosse's reflecting telescope.—Gaydon(8) has informed the French Academy that he manufactures very cheap, and at the same time very useful lenses out of spheres or hemispheres of molten glass or rock crystal, which magnify from 50 to 400 times—Peytal(9) describes the advantages of an apparatus, discovered by himself, to be worn by short-sighted people instead of the customary concave lenses. The apparatus consists of two combinations of lenses after the manner of Galileo's telescope, but only about 10 millimetres long, and not sensibly magnifying. Peytal has given to the apparatus the name *Callioscope*.

Valz(10) proposes a new kind of telescope, for astronomical use especially, called by him the reciprocal telescope; it renders unnecessary the inconvenient reversal of the horizontal axis of the instru-

(1) Instit. 1850, 395, 412.

(2) Annual. Report for 1849, III, 92, 136.

(3) Pogg. Ann. LXXIX, 437.

(4) Instit. 1850, 397

(5) Phil. Mag. [3] XXXVII, 69

(6) Instit. 1850, 398.

(7) Phil. Mag. [3] XXXV, 522

(8) Compt. Rend. XXX, 141, Instit. 1850, 49; Rev. Scientif. Industr. XXXVIII, 73.

(9) Instit. 1850, 53, 180.

(10) Compt. Rend. XXX, 287, Instit. 1850, 82.

ment. Two object-glasses are placed at the opposite ends of a tube, and also the eye-pieces belonging to them, are so arranged that they intercept as little light as possible. Valz explains how the optic axes of the reciprocal system of lenses can be placed parallel to one another.—As Valz also proposes achromatic eye-pieces of crown and flint-glass, we refer, with respect to this, to a construction described by Kellner(1) in last year's Report.

Reade(2) proposes, in order to avoid the reflection at the interior surfaces of the lenses of the eye-piece, to fill the space between the field-glass and eye-glass with water. The communication which lies before us is not of a kind to enable us to obtain a more accurate idea of the construction aimed at or carried out by Reade.

Test-Micrometer.—Unger(3) communicates, that although the microscopes by Plössl at first were only able to resolve into single lines the first 7 groups of the 15 groups of Nobert's micrometer test, while Nobert's microscopes resolved also groups 13 and 14, this difference is removed by Plössl, simply by the use of a suitable mode of illumination. The mirror is moved in the new arrangement by means of two arms in the surface of a sphere, so that the lines can be so illuminated from the side as to throw the greatest shadows possible. Under these circumstances Plössl's microscopes resolved 10 groups of Nobert's test with a magnifying power of 150, with a magnifying power of 210, 12 groups, and with a magnifying power of from 360 to 375 all the 15 groups.

Microscope-Micrometer.—Welcker(4) has invented a new microscope-micrometer. In the focus of the eye-piece is a cross consisting of two fine spider-lines or lines engraved on glass perpendicular to one another, whose point of intersection is placed excentrically. By turning the eye-piece, which is secured by a cone placed round the microscope-tube, an index attached to the eye-piece measures on a graduated circle of arbitrary radius, attached to the microscope, the arc which must be described in order that the intersection of the wires of the eye-piece may coincide first with one end, then with the other of the dimension to be measured. A special arrangement applied to the object-stage, allows a very delicate insertion of the object in a manner adapted to measuring.—The mode of making the scale is described in the memoir quoted. If the divisions of the scale are to correspond immediately to a usual measure, a good glass micrometer must be employed in the first instance, and besides this, a separate scale must be used for each magnifying power, of which,

(1) Annual Report for 1849, III, 89.

(2) Instit. 1850, 364.

(3) Pogg. Ann. LXXIX, 331.

(4) Henle and Pfeufer's Zeitschr. für Ration. Medicin, X, 1.

Micro-
scope-
micro-
meter.

however, several may be easily connected together. The measuring with the micrometer described is not difficult, and supplies, as from the simplicity of the principle might be expected, a greater accordance in the measurement of small fractions of a line than is usually obtained by the application of other micrometers. Welcker has convinced himself of the want of agreement between the glass micrometers made by different artists, and considers it desirable that a determinate standard measure should be fixed on for micrometry.

Hessel(1) describes an apparatus called by him the colour-changing apparatus, which enables the colours which the surfaces of minerals show at different angles of incidence, and for different azimuths of the incident light, to be conveniently observed. With reference to his theoretical views concerning the changes of colours, Hessel refers to a memoir published a long time ago(2).

Polariscope.—Sénarmont(3) describes a polariscope which both shows small traces of polarization, and also determines most accurately the direction of polarization. The instrument consists of four exactly equal right-angled prisms of quartz, each two, which consist of quartz of opposite rotating power, placed with their basal surfaces on one another, so that the refracting edges fall in a straight line. These compound prisms have their hypotenusal surfaces placed against one another, so that the left-hand rotating half of the one, and the right-hand rotating half of the other, and *vice versa*, form a parallelepipedal plate whose parallel surfaces are perpendicular to the optic axis. If now a polarized pencil of parallel rays passes through in the direction of the axis, a quantity of black fringes are seen parallel to the refracting edge of the prisms. If the principal section of the analyser is perpendicular to the plane of vibration of the polarized light, the central fringe of the extraordinary image corresponds to the position where the oppositely lying prisms have equal thickness.—If, however, the principal section of the analyser is turned, the central fringe is displaced, and removed farther from the refracting edge of that prism of quartz whose rotating power has the same direction as the rotation of the analyser. This displacement, therefore, takes place in opposite directions in the two halves of the plate, and the central fringe appears broken. Here then is a simple and sensitive means of ascertaining the direction of polarization which is applicable as well for white light as for homogeneous light, and even for elliptically polarized light, although in the latter case the fringes are paler.—Sénarmont found the polariscope to be better the less the hypotenusal surfaces were inclined to the optic axis, and the closer and

(1) Pogg. Ann. LXXIX, 412.

(2) Kastner's Archiv für die gesammte Naturlehre, X, 273.

(3) Ann. Ch. Phys. [3] XXVIII, 279; Pogg. Ann. LXXX, 293.

sharper, therefore, the fringes appeared, only the latter had to be magnified by a small telescope.

New Compensator and Saccharimeter.—Duboscq and H. Soleil(1) have applied an alteration to the saccharimeter(2), which was rendered necessary, inasmuch as the quartz plates, 60 millimetres long and of perfect purity, which were requisite for the compensator, could no longer be obtained.—The new compensator consists of two cubes, 12 millim. in the edge, each of which is composed of two prisms whose angles are 35° , of opposite rotating power. The two cubes are placed against one another, so that two prisms of similar direction of rotation abut against one another, and form a plate with parallel surfaces. The smallest displacement of one cube or the other produces a rotation of the plane of polarization in the direction of the predominant thickness of quartz. The displacement itself is effected by means of a micrometer screw, the head of which is divided into 200 parts, and the distance of the threads of which is 2 millim., so that it can be read to the hundredth of a millimetre without a vernier. Duboscq and Soleil consider this instrument more convenient than the previous construction of the compensator.

New compensator and saccharimeter.

Apparatus for the application of photography to the self-registration of meteorological and magnetical observations, have been invented by Brooke(3) and Lefroy(4).

Optics of the Atmosphere. Absorption of the Light by the Atmosphere.—Jacob(5) has found opportunity in his geodetical operations to make observations on the absorption of light by the atmosphere. If such were not the case, in signalling with the heliotrope, the distance at which the light is visible in a straight line would (all other circumstances being supposed the same) be exactly proportional to the aperture of the reflector. In the mean of numerous observations, however, the results were as follows :

Actual distances.	Apertures of the heliotrope reflector.	Proportional distances.
15 English miles.	0.5 English inches.	15
23 "	1.0 "	30
33 "	2.0 "	60
45 "	4.0 "	120
60 "	8.0 "	240

According to this, the loss of light in passing through one mile of atmosphere at a pressure of 27 inches, amounts to 0.0610 of the whole.

(1) Compt. Rend. XXXI, 248; Instit. 1850, 266.

(2) Annual Report for 1849, III, 84.

(3) Phil. Trans. for 1850, Part I, 83; Phil. Mag. [3] XXXV, 544.

(4) Sill. Am. J. [2] IX, 319.

(5) Proc. of Edinb. Royal Soc. II, 36; Sill. Am. J. [2] X, 129.

State of
polariza-
tion of the
atmo-
sphere.

State of Polarization of the Atmosphere.—Bravais(1) has observed the state of polarization of the sky while the sun was surrounded by a halo of 22° . From the zenith to a distance of 30° from the sun the polarization was vertical; then there was a neutral point where distance from the sun varied between 25° and 30° , according to the brightness of the halo. Then followed horizontal polarization, which was strongest on the halo itself, as Arago also found previously. Within, the same polarization continued though very weak, even to within 3° of the sun. The proportion of polarized light there was about one-fiftieth. The same strange state of polarization also occurs when there is no halo, and only the light grey veil of clouds is before the sun which usually occasions that phenomenon. The neutral point is then distant 25° from the sun. The same arrangement of the spots of polarization is also found below the sun, only the lower neutral point, on account of the proximity of the horizon, is somewhat farther from the sun. Bravais found in one case 33° .—If portions of the sky are observed at the same altitude as the sun, to the right and left, outside the halo the horizontal polarization is found to a distance of 25° from the sun where there is a neutral point. On the halo itself the polarization is vertical, but at the inner boundary of it becomes suddenly horizontal again, and remains so to a distance of from 5° to 10° from the sun according to the state of the atmosphere and the altitude of the sun above the horizon.—When the sun has an altitude of only 8° or 10° , and the halo is faint, the neutral points of the inner and outer edges coincide on the halo itself.

Brewster(2) has made observations on the position of the two neutral points of atmospheric polarization which were discovered by Arago and by Babinet. Brewster will communicate a full description of the results after a more accurate calculation of the altitudes of the sun. They show the increase of the distance between the neutral point and the anti-solar point after sunset. The observation of the state of polarization during a halo round the sun of 45° radius, afforded especial interest. Brewster observed it at the moment of the greatest brightness, with the polariscope with rectilinear bands. These appeared brightest when they crossed the arc at its highest point at right angles, and weakest when the crossing took place in a horizontal direction. It follows from this that the light of the halo was principally polarized in the vertical plane. Brewster remarks, that this may depend on the fact that the greater number of the crystals of ice producing the halo have their axes directed vertically, that, however, the same effect would be produced if the crystals of ice

(1) Instit. 1850, 140.

(2) Compt. Rend: XXX, 533; Instit. 1850, 252; Arch. Ph. Nat. XIV, 146.

had the form of what Talbot calls analyzing crystals, which in certain regions only transmit one of the two rays of light separated by double refraction.

Physio-
logical
optics.
Theory of
vision.

Physiological Optics. Theory of Vision.—Valée(1) has continued his investigations concerning vision(2). He is of opinion that when the eye has accommodated itself to a distant object, for instance, when it views a distant landscape: 1. the axes of the pencils of rays proceeding from the distant points are normal to the retina; 2. the two extreme portions of each of these axes, which consist of broken lines, namely, the part adjoining the point of the object, and that adjoining its image on the retina, are parallel to one another; 3. the straight lines which join those two points are nearly normal to the retina. Farther, Valée is of opinion that in consequence of the layers of different density in the crystalline lens, just so many different images must exist of the same point, separated from one another, unless the vitreous humour, by its unequally dense structure, again neutralized this effect of the crystalline lens. We have not as yet seen experimental proof or theoretical basis either for this original view or for the remaining opinions of Valée.—Valée(3) says, in a second note, that he has furnished a proof, in a geometrical manner, that the density of the crystalline lens must decrease from the outside to the inside. That this may be indeed opposed to the opinions of anatomists, physiologists, and physicists, and to the results of the measurements hitherto made in connection with it; but nevertheless it is correct, for spherical layers of a density decreasing outwards must, on account of total reflection at the hinder surface, form a completely opaque body.

Inversion of the Image on the Retina.—Dezautière(4) is of opinion that the turning round of the inverted image on the retina into the upright position takes place by means of the retina itself, by this latter acting as a concave mirror. He is silent, however, as to how the optic nerve is to receive the impression of this image standing upright in the focus of this concave mirror.

Number of all Possible Visual Impressions.—Doppler(5), assuming a square whose apparent edge is 50 seconds as the smallest perceptible surface, and a million as the number of distinguishable shades of colour, has calculated that on a square inch (Austrian measure), at a distance of 10" from the eye, $10^{25528152}$ different visual perceptions are possible. Farther, going on the supposition that the eighth part of the spherical field of view is visible at once, he

(1) Compt. Rend. XXX, 139.

(2) Annual Report for 1847—48, I, 165.

(3) Compt. Rend, XXX, 644.

(4) Instit. 1850, 363.

(5) Zwei Weitere Abhandlungen aus dem Gebiete der Optik, Prague, 1848, No. I.

Single and
double
vision.

calculates that a man, in a life 120 years long, can receive (1000000) ¹³⁴⁹⁶¹⁸⁰²¹⁹⁶⁶¹²⁸⁰⁰⁰⁰⁰ different visual impressions.

Single and Double Vision.—Lathrop(1) has made experiments on the double images, which are obtained of two, three or more points, by a great convergence of the axes of the eyes, and on the positions which these images assume when the head is inclined to the right or to the left. No new results for the physiology of the eye were obtained from these experiments.—Locke(2) has constructed an especial, and very simple apparatus, for experiments of the kind just described, and called it the *Phantascope*. The objects which are to be superposed on one another are laid on the foot-board of the apparatus. At the upper end of a vertical rod, which is fixed on the foot-board, is a second horizontal board, with a slit as long as the distance of the two eyes; a third board, with an opening 3 inches long and 1 inch broad, whose centre is marked by an index, slides on the vertical rod between the foot-board and the eye-board, and the index serves as a point to which the two axes of the eyes may be directed. From the numerous experiments which Locke made, it need perhaps only be mentioned, that he could not bring two parallel lines into coincidence along their whole length, since they always were separated at one end when they coincided at the other. Other persons observed the divergence in exactly the opposite direction.

Subjective Appearances of Light.—Serre(3) has published a memoir on the subjective appearances of light, which are produced by pressure on the eye with the finger, or with another object.

Stereoscope and Allied Instruments.—When an image with differently coloured compartments is looked at with both eyes through a lens of at least 2.5 inches diameter, the compartments which emit rays of smaller refrangibility appear nearer than those covered with the more refrangible colours. The origin of the phenomenon, according to Brewster(4), is this, that each eye looks through the edge of the lens as through a prism, and the double images which thus arise from a blue compartment, on account of their greater deviation, are separated farther from one another than the images of a red compartment. When, however, the eyes unite the two images into one, as in the stereoscope, the elementary images, which are farther from each other, are united into a more distant double image. Brewster is of opinion, that by different colouring, a relief might be obtained in this way, especially if lenses were used of very great dispersive power, as of flint-glass, oil of

(1) Sill. Am. J. [2] VII, 343.

(2) Sill. Am. J. [2] IX, 153; Phil. Mag. [3] XXXVI, 453.

(3) Compt. Rend. XXXI, 375.

(4) Inst. 1850, 128.

cassia, &c.—A farther description is now before us(1) of a new stereoscope, constructed by Brewster, of which already mention has been made in last year's Report(2). The above physicist will make more extended communications on such instruments in the "Transactions of the Royal Scottish Society of Arts."—Duboscq(3) describes one of the Brewster's stereoscopes mentioned(4), in which two half-lenses of 18 centimetres focal length are employed, and so directed that two Daguerreotype pictures, taken at slightly different angles, when examined through the lenses, unite and give the impression of an object in relief. Duboscq also finds the apparatus adapted for mixing complementary images to form white, and for many other experiments having reference to the physiology of vision.—Dove(5) draws attention to the fact, that a stereoscopic relief may be obtained by means of a single drawing, by placing before one eye a Galileo's telescope, and before the other an astronomical telescope, both of equal magnifying power. If the telescopes are interchanged, the same inversion is obtained as in the Wheatstone stereoscope, by interchanging the two drawings; the object previously seen as embossed, appears now sunk.

Particular Phenomena of Binocular Vision.—Dove(6) remarks, that a line may be seen double at pleasure; and that it happened to him in a case of that sort, that the one end of one of the images appeared displaced, as if broken off. This, he says, may also happen in both images; in this way a straight line may even appear as a partially curved one.

Optical Illusions.—Lovering(7) draws attention to the optical illusion which easily occurs when a revolving wheel, the sails of a windmill, or the like, is so observed that the plane of rotation nearly coincides with the axis of vision. The rotation seems to take place sometimes in one direction, sometimes in the other; and the plane of the rotating wheel makes little oscillations, so as to appear first on the one side, then on the other. Lovering explains this phenomenon by saying that the eyes lack the means of deciding which is the nearer and which the more remote part of the revolving disc, and therefore that sometimes one opinion prevails and sometimes the other.

(1) Report of the 19th Brit. Assoc. note and abstract, 6.

(2) Annual Report for 1849, III, 99.

(3) Compt. Rend. XXXI, 895.

(4) Annual Report for 1849, III, 99

(5) Pogg. Ann. LXXX, 446; Berl. Acad. Ber. 1850, 152; Arch. Ph. Nat. XV, 219; Instit. 1850, 315.

(6) Berl. Acad. Ber. 1850, 363.

(7) Proceedings of the American Association for the Advancement of Science, held at Cambridge, 1849, 369.

Depen-
dence of
the inten-
sity of
light on
the dura-
tion of the
impress-
ion.

Dependence of the Intensity of Light on the Duration of the Impression.—Swan(1), from his experiments on the relation between the time of action of a source of light, and the intensity of the impression on the retina, has obtained the following results: 1. The brightness of luminous appearances of given intensity, and of such quick succession that they produce a uniform continuous impression, is proportional to the number of impressions in a given time. 2. The intensity of a luminous impression is for a very short duration (shorter than $\frac{1}{10}$ second), proportional to the time it lasts. This law has been proved from $\frac{1}{8 \cdot \frac{1}{32}}$ to $\frac{1}{4 \cdot 1}$ of a second. The strength of the impression in $\frac{1}{10}$ of a second is $\frac{1}{10}$ that of continuous light, from which it follows that the impression of continuous light is completely attained in $\frac{1}{10}$ of a second. 3. Light of various intensities, as well as of different colours, acts equally quickly. 4. Since the duration of the electric spark, according to Wheatstone, does not reach the millionth part of a second, it would, for a duration of $\frac{1}{10}$ of a second, be at least 100000 times as bright.

Duration of Impressions on the Retina.—Plateau(2) describes an interesting case of optical illusion, which depends on the duration of the impressions on the retina. On a black disc of 25 centimetres diameter, a white stripe 2^{mm} broad proceeds out from the centre, in the form of the spiral of Archimedes, to the circumference. If this disc is turned quickly round, say 6 or 7 times in a second, and observed with the eyes directed to the centre, or to the circumference, the appearance is presented of white circles on a black ground, which either start from the centre and proceed to the circumference, or the contrary, according as the rotation takes place in the direction in which the spiral proceeds inwards or outwards. If the first phenomenon, for instance, has been watched a sufficient time, yet not so long as to fatigue the eyes, and the attention is then directed to another object—for instance, to the head of any person—this appears for a while to grow smaller, or, on the contrary, to increase, if we have been observing the opposite appearance of the spiral.—Plateau looks on this phenomenon as a new argument in favour of the principle enunciated by him, of which the following is the purport: As soon as an organ is subjected to a long excitement, it opposes a resistance to it, which increases with the duration of the exciting cause. If it is suddenly withdrawn from this exciting cause, it attempts to regain its normal state in the same way as an elastic spring, which, displaced from its position of equilibrium, returns to it by decreasing oscillations.—The accidental colours in

(1) Sill. Am. J. [2] IX, 443; Instit. 1850, 399.

(2) Pogg. Ann. LXXX, 287, from Bull. de l'Acad. Roy. de Belg. XVI, No. 10; Inst. 1850, 5.

particular have furnished Plateau with examples of this law—examples in which he was able to follow the phenomenon up to 5 negative phases, which alternated with positive ones. At times, he could only perceive a series of negative phases, probably because the intervening positive ones were too weak.

Defects of
the eye.

Defects of the Eye.—Stokes(1) remarks that the defect of unequal curvature of the refracting surfaces of the eye in different directions, is easily detected by observing a small opening in a card. That, at a certain distance from the defective eye, this appears elongated in one direction; at length, spread out in a line, and that for a still greater distance, this line again contracts, and the image elongates itself in a direction perpendicular to the previous one. To find out the form of a cylindro-spherical lens(2), which will correct the defect of the eye, Stokes proposes to adapt to one another two cylindrical lenses of equal but opposite curvature, in such a manner that one may be turned in its own plane, and the amount of rotation measured. In a certain position, the influences of the two lenses exactly destroy one another. A person with a defective eye must turn the one lens from this position, till the defect of his eye is completely corrected. The nature of the requisite spectacles may then be easily calculated from the angle of rotation. Stokes communicates some additional laws which relate to lenses with cylindrical curvatures.—Farro(3) has found that in a sick person whose pupil had closed, and to whom a side pupil had been given artificially, the crystalline lens has turned round about 45° from its previous position, and adapted itself to the artificial pupil in such a manner as to bring about distinct vision.—D'Hombres-Firmas(4) has given a continuation of his collection(5) of cases of achromatopsy, and on this occasion he described some experiments which he has made with the individuals in question.—Cranmore(6) describes a defect of the eye, consisting in this, that he saw with the left eye, the right being closed, and conversely, a square drawn with black lines on white paper, double, the one image displaced somewhat towards the inner angle of the eye and upwards, and the intermediate space between the two contours coloured a red brown. Through a fine slit in a card, Cranmore saw that contour single, to which the slit was held parallel; through two fine holes, pierced with a needle, the whole square appeared single, with a clear outline.

(1) Report of the 19th British Association, notes and abstracts, 10.

(2) Annual Report for 1849, III, 105.

(3) Arch. Ph. Nat. XV, 216, from Athénée de Venise.

(4) Compt. Rend. XXX, 57, 376.

(5) Annual Report for 1849, III, 105.

(6) Phil. Mag. [3] XXXVI, 485.

The coloured
light of the
double
stars.

The Coloured Light of the Double Stars.—Doppler(1) cites, with reference to his opinion on the cause of the coloured light of the double stars, those confirmatory observations which have been already published by us in a previous Report(2), at the same time with the vindication of Doppler's right of priority. He then adds a new series of observations, which have been made by Sestini at the *Collegio Romano*, on the coloured light of the fixed stars, and which are likewise looked on by Doppler as a confirmation of his views. By these Sestini found that not merely double stars, but also very many single fixed stars, have coloured light, and indeed the half of all of them yellowish light, with slightly-coloured shading, $\frac{1}{2}$ white light, $\frac{1}{2}$ orange-coloured light, and $\frac{1}{16}$ light of other colours.—The white stars, according to him, occur for the most part between 60° and 90° of northern declination; the coloured ones from 30° northern to 30° southern declination, without however this zone being exactly parallel to the equator. In the northern half of this zone, he says, blue and violet stars chiefly occur; in the southern half, orange-coloured and red. In no place are so many blue and violet stars to be found as in the neighbourhood of the constellation Hercules, which brings the opinion of Doppler into accordance with the motion of our planetary system towards that constellation, which has been proved by Herschel and Argelander. That single fixed stars are also subject to changes of colour, Sirius and β Geminorum serve as examples. The number of coloured double stars has been farther increased by Sestini's observations.

Haidinger's Brushes.—Brewster(3) communicates a short remark on Haidinger's Brushes, from which it appears that he explains this phenomenon in the same manner as Silbermann(4). A single difficulty, says Brewster, still remains, namely, that the direction of the brushes is parallel to the plane of polarization, while it ought to make an angle of 45° with it.

Stokes(5) has remarked, that with different coloured tourmalines, and with Nicol's prisms, combined with different coloured glasses, Haidinger's brushes are seen with different degrees of distinctness; for many colours, not at all. He was induced by this to investigate the appearance of the brushes in the different parts of a pure spectrum thrown upon white paper, in which Fraunhofer's lines were visible. In the red, orange and yellow, the brushes were not visible at all, but first in the green, from the line *E*; they were

(1) Pogg. Ann. LXXXI, 270; Wien. Acad. Ber. July, 1850, 154.

(2) Annual Report for 1847 and 1848, I, 122.

(3) Instit. 1850, 325; Sill. Am. J. [2] X, 394.

(4) Annual Report for 1847 and 1848, I, 159.

(5) Instit. 1850, 325; Sill. Am. J. [2] X, 394.

very apparent in the blue, at the line F , and could be traced as far as the line G , while the more remote part of the spectrum was too dull for observing the phenomenon. In the blue field the brushes were not specially coloured, but only darker than the remaining part of the field.—Stokes remarks, that from these facts the yellow colour of the brushes may be immediately explained, since their origin depends on the absorption of a certain quantity of the more refrangible rays. By lamplight, therefore, which contains a preponderance of red and yellow rays, Stokes could only observe the brushes by making use of a blue glass in addition to the Nicol's prism. On the peculiar origin of the brushes, this explanation of Stokes contains nothing.

Haidinger's
brushes.

Chemical Action of Rays of Light.—Wartmann(1) has exhibited the polarization and interference of the chemical rays by means of two Nicol's prisms, whose dimensions are described as follows: Polarizing prism, $0^m.86$ (?) long, $0^m.036$ and $0^m.028$ broad; analyzing prism, $0^m.07$ long, and in the direction of the two diagonals $0^m.03$ and $0^m.023$ broad.—The light passed through these prisms, and then, by means of the usual lenses, fell on a daguerreotype plate made as sensitive as possible in the camera obscura. When the principal sections of the prisms were inclined at an angle of 45° , a sharp portrait of a person was obtained in eighty seconds; when, on the contrary, that angle was 90° , no picture of a person was obtained in three minutes; also an almost directly illuminated lithograph gave no trace of a copy. On the contrary, when the angle of the principal sections of the two Nicol's prisms amounted to 70° , a tolerably distinct picture was produced in four minutes.—R. Hunt(2) has given an excellent compressed review of our knowledge of the chemical action of luminous rays, which is well worthy of being read. We do not insert it here, because it contains no new facts.—Claudet has endeavoured, by means of a judicious apparatus, to give a surer foundation to the extremely fluctuating effects of photographic methods. His *Photographometer*, which serves to test and compare the sensitiveness of the plates, has been already previously described(3).—In order to determine the most suitable distance for a given arrangement of the lens apparatus, at which to bring the object to be represented before the lens, Claudet(4) makes use of a number of sectors, which are placed on the circumference of a cylinder, at equal angular distances, on a spiral line. The axis of the cylinder is directed to the instrument, and it is found which sector is most sharply depicted.—A third

(1) Arch. Ph. Nat. XV, 214.

(2) Instit. 1850, 327.

(3) Annual Report for 1847 and 1848, I, 179; Annual Report for 1849, III, 107.

(4) Instit. 1850, 391; Sill. Am. J. [2] X, 401; Compt. Rend. XXXII, 130.

Chemical
action of
rays of
light.

instrument, the *Dynactinometer*, serves to determine accurately the time of the action of the light. A black plate is set up at a proper distance, and by clock-work a disc is so set in motion, that in each second one division more of a sharply-divided sector of white paste-board becomes visible. That division, which is depicted most sharply indicates how many seconds the most profitable time of action amounts to.

Photography.—Blanquart-Evrard(1) communicates that he has verified a means of obtaining perfect pictures in a very short time, first proposed by a Munich photographer named Laucherer. It consists in lining the inside of the dark camera and the setting of the lenses with white paper. The method offers the following advantages, as well for pictures on silver as on albumen and paper: 1. the picture is produced in half the time which is required in the blackened camera; 2. a good picture is obtained with an illumination, which would be insufficient with the blackened camera; 3. the photographic action is more uniform, because the light parts are not spoiled before the twilight parts have properly shown themselves; 4. the colours which otherwise do not readily act photographically, as red, yellow and green, appear more easily.

Nièpce de St. Victor(2) obtains light pictures on silver plates in the following manner, without making use of iodine and mercury. He immerses the silver plate in a warm bath of chloride of potassium and sulphate of copper, takes it out after some seconds, washes it with distilled water, and dries it with a lamp.—He then lays a drawing or an engraving on the plate, covered with a plate of glass, and lets either the sunlight act for half an hour, or the diffused daylight for two hours. The picture is not always visible; but it appears distinctly as soon as it is immersed in diluted ammonia. Cyanide of potassium also, or hyposulphite of soda, serve for this purpose. The plate must, however, be placed in distilled water as soon as the unchanged chloride of silver is taken away. The picture can then be fixed by the gold solution.—A daguerreotype picture is obtained with the chloride of silver plate in the camera obscura, if the sunlight is allowed to act for one hour, or the daylight for two or three hours.

Bousignès(3) describes a method by which positive pictures may be obtained immediately on paper. Some sheets of thin paper are moistened with distilled water, and laid on one another on a plate of glass, that one at the top which is to receive the picture. After the dampness has disappeared, three or four drops of neutral nitrate of silver are dropped on them, and rapidly spread with a brush. The

(1) Compt. Rend. XXXI, 864; Instit. 1850, 409.

(2) Compt. Rend. XXXI, 491; Instit. 1850, 313.

(3) Compt. Rend. XXXI, 630.

traces of the solution disappear in a few moments, and the paper is thenceforward treated as a silver plate. It is then subjected for fifteen seconds to the vapours of iodine, then for thirty-five seconds to the vapours of bromine, and finally for ten seconds again to the vapours of iodine. The plate is then introduced into the camera obscura, and the picture is rendered visible by the vapours of mercury. As for the rest, Bousigués(1) remarks that it is not easy to measure properly the time of action of the rays of light which is requisite for a positive picture. That if the paper, when subjected to the mercurial vapour, assumes a uniform dark tint, it is a sign that the light has not acted long enough; if the paper remains altogether white, the light has acted too long. He states also, that the methods described are applicable to sheets of albumen and gelatine.

Middleton(2) recommends the following method of preparing photographic paper. White of egg is beaten till it becomes fluid; it is then mixed with water in the ratio of 1:6. To 17 parts of this mixture is added 1 part of iodide of potassium. The paper is kept in contact with this solution for three or four minutes on the side which is to be made sensitive, having been first washed with a brush and dried again, it is then allowed to drain and dry, and is preserved.—Before use it is treated, by means of a glass rod, with a solution of 3 parts of nitrate of silver and 4 parts of acetic acid in 24 parts of water, and dried in the dark. In putting it into the camera and taking it out again, yellow light should be employed. With ordinary sunlight the sheet should remain in the camera ten or fifteen seconds.

Poitevin(3) describes a process for replacing the film of albumen hitherto used upon glass by a thin film of clear gelatine. 6 grms. of gelatine are dissolved in 100 grms. of water, the solution is scummed, filtered through fine linen cloth, again scummed, and then applied, by means of a small pipet, to the plate of glass which has been already previously moistened with a more diluted solution of gelatine by means of a small piece of linen cloth. The film of gelatine must have a thickness of at least 1.5^{mm} ; it is diffused quite uniformly whilst it is heated, and is then allowed to cool. The plate is then dipped in a solution of nitrate of silver; this is brought into intimate combination all over with the film of gelatine by means of a soft brush, and is allowed to dry perfectly for five or six hours, while it is carefully protected from the light.—When it is to be used, it is previously subjected to vapours of iodine like a silver plate; some time is then allowed to expire, to leave time for the plate to become somewhat more sensitive, and it is then introduced into the camera,

(1) Compt. Rend. XXXI, 726.

(2) Phil. Mag. [3] XXXVII, 178.

(3) Compt. Rend. XXX, 647; Instit. 1850, 169; Rev. Scientif. Industr. XXXIX, 307.

Photo-
graphy.

the back side being covered with a black cloth. The sensitiveness is about 4 times less than that of a silver plate which has been exposed to the vapours of iodine and bromine. Eighty or a hundred seconds suffice for a landscape well illuminated, two minutes for a portrait.—To render the picture visible, the plate is dipped in a solution of 1 part of gallic acid in 1000 parts of water from an hour to an hour and a half. Afterwards the picture is fixed by hyposulphite of soda, and washed with water.

Humbert de Molard(1) describes two new methods of treating the albumen upon glass. He covers the plate of glass with pure albumen, allows it to dry, and then coagulates it by a quick immersion in nitric acid, which is then as quickly neutralized again by transferring the plate into a solution of ammonia. The plate then has a milky appearance. The plate is then washed, dried, washed over by means of a brush with fluid iodide of silver, and dipped in water, when it assumes a golden-yellow colour. After it has been again washed and dried, the plate can be preserved. Before use, it is then prepared in the customary manner.—The second remark of Molard regards the application of syrup, honey, the serum of milk, and many other substances, in order, by mixing them with albumen, to render the coating of the photographic plates softer and more like paper.—Regnault(2) remarks, with reference to this latter point, that Niépce de St. Victor has long since employed the same process with success, and Niépce(3) himself describes his process in the following manner: For each white of an egg 2 or 3 grms. of honey are taken, and 30 or 40 centigrms. of iodide of potassium; and after the albumen has been beaten as usual, the mixture is spread uniformly over the glass plate. When this has dried, the plate is dipped for ten seconds in a solution of 5 parts of nitrate of silver and 12 parts of crystallizable acetic acid in 60 parts of water, then washed and dried in the dark. Niépce farther recommends the placing a white sheet behind the prepared plate in putting it in the camera obscura, and in dipping it in gallic acid, to warm the latter a little, since the best negative pictures are often obtained, when at first there seemed to be no picture at all. It is then to be fixed with bromide of potassium or hyposulphite of soda, and the negative picture covered with a coating of gelatine or varnish to prevent the albumen from chipping off.—Honey is, according to Niépce, of all accelerating substances the least dangerous, while, for example, the compounds of fluorine are inconvenient on account of their corrosive properties. Yet in particular fluoride of ammonium mixed with

(1) *Compt. Rend.* XXXI, 208; *Rev. Scientif. Industr.* XXXIX, 375.

(2) *Compt. Rend.* XXXI, 210.

(3) *Compt. Rend.* XXXI, 245; *Instit.* 1850, 266; *Rev. Scientif. Industr.* XXXIX, 379, 382.

honey is an excellent accelerating medium. Moreover, the action is quicker the thicker the film of albumen, the older the eggs are whose white is employed. Yet the older albumen scales off particularly easily if it is not softened by the addition of honey, or protected by a coating of varnish. Some other remarks which Niépce has collected in his study of photography, can be seen in the memoir cited.

Blanquart-Evrard(1) has endeavoured to discover methods of so facilitating photography that every one may make use of them without special training. He describes first a preparation of paper which allows it to be dried and kept dry till used. To half a litre of whey, which has been obtained clear by filtering, the white of an egg is to be added; it is then to be heated till it boils, again filtered, and then, when cold, 5 per cent of iodide of potassium is to be dissolved in it. The paper is now immersed for two minutes, and then fastened by the corners with two needles to a stretched cord, and dried. Paper thus prepared may be preserved several months without losing its usefulness. The farther preparation before using is effected by candle-light by the method already previously described by Blanquart(2). The duration of the action of the light in the camera varies according to the intensity of the light, and the object-glass employed, from one to five minutes.—Blanquart states, that instead of the mixture of serum and white of egg, albumen alone may be used for the preparation of dry sheets for the negative as for the positive pictures, and describes accurately the method of proceeding.

In another communication Blanquart-Evrard(3) discusses the accelerating power of fluoride of potassium. The preparation with iodized albumen on glass, which otherwise possesses the least sensitiveness, and requires the light to act 60 times as long as the prepared paper, becomes so sensitive by the addition of fluoride of potassium, and by washing the plate, after dipping in the solution of nitrate of silver, with a solution of fluoride of potassium instead of with distilled water, that the pictures appear when the light has only acted an instant.

Aubrée(4) recommends the following process for furnishing the positive light-pictures with a tone of colour which may have any shade at pleasure, from red to black. After the positive picture has been obtained in the usual manner, it is to be left for a quarter of an hour in the bath of hyposulphite of soda, and then placed in a solution of 4 grms. of nitric acid in 250 grms. of water, where it then visibly grows darker, and can be taken out when it has assumed the desired shade.

(1) *Compt. Rend.* XXX, 663; *Instit.* 1850, 267; *Rev. Scientif. Industr.* XXXIX, 305.

(2) *Annual Report* for 1847 and 1848, I, 175.

(3) *Compt. Rend.* XXX, 779; *Instit.* 1850, 193.

(4) *Compt. Rend.* XXX, 747.

Photo-
graphy.

Martin(1) communicates, as a result of his study of the positive light-picture upon paper, that it is more beautiful, the more concentrated the salt-solutions are prepared, especially the silver-solution; farther, that the beauty of the pictures is promoted by more often applying the photographic substances in such an alternation that new precipitates are continually formed. That machine-made paper is the less suitable for positive pictures the more starch is used for its sizing, that English-made paper is the best. Martin then gives a series of instructions for obtaining pictures of a "mouse-grey, purple-brown, velvet-black, and blue-black" colour.

Malone(2) describes a process for converting the negative albumen picture on glass immediately into a positive picture. For this purpose, while the red-brown picture is developed under the action of the gallic acid, a concentrated solution of nitrate of silver is to be poured on the plate. The picture will then, he says, first become black, and finally pass into the opposite positive picture, by the lights being produced by metallic silver.—Wheatstone has proposed to replace the plate of glass by blackened wood or blackened ivory, that the shadows may stand out better.

Jacobi(3) has communicated a process discovered and practised by Peschel for copying daguerrotype pictures by the electrotype process, which offers remarkable results. He mentions as a circumstance worthy of note, that on the back of the galvanic deposit of copper a tolerably sharp reversed picture is seen, even when the layer is 0.5^{mm} thick.

Magnetism. Lifting Power.—The mechanician Logeman in Haarlem, prepares steel magnets according to the method of Elias(4), the strength of which, in comparison to the quantity of steel, is said to be unusually great(5). A small horse-shoe magnet, weighing 0.51 kilogrammes, which was tested by Poggendorff(6), possessed a constant lifting power of 31.5 lbs., a force which, as Poggendorff remarks, is more than twice as great as that required by the formula of Häcker(7). The influence of the form of the keeper in these experiments is not mentioned.

The lifting power of electro-magnets of the horse-shoe form, has

(1) Wien. Acad. Ber. January, 1850, 11.

(2) Athen. No. 1179, 589; Sill. Am. J. [2] X, 285.

(3) Petersb. Acad. Bull. IX, 131.

(4) Annual Report for 1849, III, 112.

(5) The magnet sent to the Paris Academy weighed 0.472 kilogr. and sustained 12 kilogr. (Compt. Rend. XXX, 485; Instit. 1850, 384).

(6) Pogg. Ann. LXXX, 175.

(7) Annual Report for 1847 and 1848, I, 180.

been recently investigated by J. Müller of Freiburg(1). His experiments corroborate the result already established by Lenz and Jacobi(2), that the lifting power of an iron core whose two poles are united by an iron keeper, is far from being proportional to the square of the magnetizing force. However, the experiments which he describes are neither so coincident among themselves nor so generally satisfactory as to justify the conclusion which he has drawn from them, that the lifting power is independent of the distance of the coils from the surfaces of the poles, and also of the length of the magnet. With regard more especially to the influence of the distance of the coils from the polar surfaces, it is very easy to come to a decision, by simply examining the effect of one and the same spiral at different distances. In this way it was found several years ago by the writer, that the lifting power of a horse-shoe magnet with long limbs increases, the more the spirals approach to the surfaces of the poles(3).

J. Dub(4) has published new experiments on the attraction of straight cylindrical electro-magnets. In his former paper(5) he contended against the law of Lenz and Jacobi, according to which, the lifting power of a straight iron core is proportional to the square of the strength of the current, or at least against its universal application. In his new and very numerous experiments which embrace not only the case where the sub-magnet and magnet are in contact, but also cases where a measurable distance (up to $\frac{1}{2}$ of an inch) existed between both, the divergence from the law above referred to always disappears whenever the pole of the magnet is not in immediate contact with the sub-magnet. He farther corroborated the result that the single coils contributed more to the development of the magnetic intensity of the poles the nearer they are to the latter. When the coils were arranged in different systems of equal power, it was found that the lifting power, with a constant current, was proportional to the square of the number of systems in action. Dub's experiments lead to the following rules which are worthy of attention, and which not only corroborate results already known, but also furnish us with information altogether new.

The magnetic force of the end surfaces increases, although in a quickly decreasing ratio, when the length of the core is increased.

The mutual attraction (the holding together) between the pole and the sub-magnet, depends not only upon the magnetic intensity of the pole, but also on the character of the sub-magnet, and stands in no

(1) Bericht über die Neuesten Fortschritte der Physik, 526.

(2) Pogg. Ann. XLVII, 410.

(3) Comp. Buff's Grundzüge der Experimentalphysik, 399.

(4) Pogg. Ann. LXXX, 494; LXXXI, 46.

(5) Annual Report, 1847 and 1848, I, 183.

Lifting
power.

simple relation to the diameter of the electro-magnet or of the sub-magnet. For a given electro-magnet the attraction increases with the length and weight of the sub-magnet. Sub-magnets of equal weight are attracted with equal force, not when in immediate contact, but within the limits of small distances.

The mutual attraction remains the same when the diameters of the iron core and the sub-magnet are exchanged.

If an iron cylinder be cut in two pieces, the one piece converted into a magnet and the other into a sub-magnet, the attraction is a maximum when both pieces are of the same size(1).

When different iron cylinders are surrounded by coils throughout their entire length, and when the current is so regulated that the strength of the latter multiplied into the number of coils always gives the same product, Dub finds that, as regards the mutual attraction of two iron cylinders, it is a matter of indifference which of the two is chosen as magnet or which as sub-magnet, and that one and the same sub-magnet is attracted with equal force by cores of different lengths and diameters but of equal weights. These rules are said to hold good even for different cylindrical sub-magnets, provided only that their weights are equal and that they are not in absolute contact, but a small distance apart.

In his investigation on the intensity of magnetic and diamagnetic bodies, Plücker(2) has described a method of ascertaining the magnetic strength at any given point of the surface of a magnet. It consists in determining, by means of a balance, the weight necessary to separate a small pointed iron cylinder (that used by Plücker was 16^{mm} long, 4.5^{mm} thick, and weighed 1.7 grammes) either immediately from the place in question or from a cone of iron placed upon it. If the weight necessary to effect this be laid gradually upon the scale-pan until separation takes place, it is found that when the weight is applied all at once, the magnet is no longer able to support the weight which it supported before the separation. We can regard either the maximum weight supported when the latter is gradually laid on, or the weight which, when immediately applied, the magnet is able to sustain, as the measure of the magnetic strength. Plücker chose the former, as it permits of more exact determination. The numbers which are obtained in this manner can, however, be hardly said to represent the magnetic intensity at the places tested. They will probably correspond to the square of the intensity. Until the ratio is accurately established, it would be difficult to estimate the value of the process as a practical mode of measurement. The method however recommends itself by its general applicability.

(1) It may be added, that a still greater effect is produced, if the coils surround half the one and half the other piece of iron.

(2) Pogg. Ann. LXXIV, 330.

By this process, Vom Kolke(1), in Aix-la-Chapelle, has made a series of measurements, with a view of determining the distribution of magnetism in the polar surfaces of an electro-magnet, in keepers laid upon the magnet, in steel-bars, as also the influence of the inductive action exerted by similar or dissimilar poles upon each other. He arrived at the general result, that in any given zone of the surface which intersects the axis of the magnet at right angles, the magnetic force is always greater at the edges than upon the surfaces. On the polar surfaces of a large horse-shoe electro-magnet, the core of which was 102 millimetres in diameter, he found that the force which held the little pointed iron-cylinder almost twice as great at the rim as at the centre. In consequence of the action of the poles upon each other, the weakest point was not the centre, but approached the centre more and more the less the two limbs could act inductively upon each other. By this mutual induction of both limbs, the intensity of the magnetism distributed over the polar surfaces was increased or lessened, according as the poles were dissimilar or similar. The central points of the two poles were 281^{mm} asunder. On each of them a keeper, having the form of a parallelopiped, 189^{mm} long, 67·5^{mm} wide, and 27^{mm} high, was so placed that two faces in the direction of the axial line were turned towards each other. As the magnetic intensity of one of the opposed parallel edges was examined, it was found that when the surfaces were caused gradually to approach each other, the intensity increased very quickly until a distance of 2·25^{mm} was attained. Beyond this limit, the exterior action diminished; and when the surfaces were brought into contact, vanished to a small residue.

Action at a Distance.—The action of straight bar-magnets on small magnetic needles, placed at a great distance, is known to be directly proportional to the magnetic moment, (M), and inversely as the cube of the distance (R) from the middle of the bar to the middle of the needle. If the bar and needle lie in the same horizontal plane, and the axis of the former be so directed that it stands perpendicular to the plane of the magnetic meridian, while its production would strike the centre of the needle, then by means of the equation $\tan \alpha = \frac{2M}{TR^3}$ (1), in which T denotes the intensity of the earth's magnetism, the deflection of the needle α may be determined beforehand. If α be determined by an experiment, the magnetic moment of the bar may be found.

This formula is not at all applicable when the distance R is less than five times the length of the magnetic bar. We must then apply the more general formula of Gauss :

Action at a distance.

$$\tan a = \frac{2M}{T} \frac{1}{R^3} + \frac{a}{R^5} + \frac{b}{R^7} + \dots \quad (2)$$

The first term only of the second member of this equation appeared in the foregoing case. The two first terms of the equation are sufficient, as long as the distance R exceeds three times the length of the magnetic bar; and to determine the moment, two observations at least, made at different distances between the needle and the bar, are necessary.

By this method, Buff(1) sought long ago to determine the action of electro-magnetic spirals and electro-magnets at a distance. With respect to the former, he found that the formula (1) gave sufficiently exact results, as long as the width of the coils, in comparison to the distance R from the middle of the spiral to the middle of the needle, is very small, and the entire length of the spiral does not exceed a fourth of this distance. By means of spirals whose dimensions fell within these limits, he then formed electro-magnets, and tested their action upon the distant magnetic needle; in this way he arrived at results which corroborated, in a satisfactory manner, the following laws discovered by Lenz and Jacobi(2).

The magnetic moment of an electro-magnet is proportional to the strength of the current which circulates around the iron core.

The total action of the wire-coils which surround an electro-magnet is equal to the sum of the actions of the single coils.

When the extreme convolutions recede sufficiently from the ends of the core, their action is independent of their distance. The magnetizing force is then proportional to the product of the strength of the current into the number of coils.

By the process above described, J. Müller has arrived at very divergent results(3). According to him, the laws mentioned are only valid for weak currents and thick iron cores. When high magnetic force is applied, the magnetic moment is said to fall behind the increasing strength of current to such a degree, that a proportionality between the magnetism of the bar and the strength of the current is not to be thought of. Müller placed his electro-magnets at a distance of 88 centimetres from the needle. His spirals were about 500 millimetres in length, his bars 560 millimetres; their length was therefore much too great, or rather their distance from the needle too small, to permit of the unconditional application of the fundamental propositions of the above method. Besides this, he omitted to take into account the residual magnetism, which in bars of such a length is far from being inconsiderable, and is impossible to be got rid of.

(1) Grundzüge der Physik, 393.

(2) Pogg. Ann. XLVII, 225.

(3) Pogg. Ann. LXXIX, 337; Phil. Mag.*[4] I, 194 (in abstr.)

Buff and Zamminer(1), therefore, conjectured that the one or other of these causes might have had an influence on the results obtained by Müller. In repeating the experiments of the latter, they really observed several divergences, which were the more strikingly exhibited as the bars possessed increased power to retain residual magnetism. Several iron cylinders, carefully chosen, and as free as possible from coercive force, behaved, on the contrary, within wide limits of magnetizing power, quite in accordance with the law discovered by Lenz and Jacobi. The thickest of these cylinders possessed a diameter of 55 millimetres, the thinnest a diameter of 9 millimetres; none of them exceeded 2 decimetres in length. With these moderate lengths it was possible to pile over each zone of the bar a great number of coils, and thus call into action a magnetizing power which was very great in comparison to the mass of iron operated on. With the thicker iron cores, this power could be increased until the maximum was forty-six times the minimum applied. With the thin cores, the nature of the wire made use of did not permit of such wide differences being measured. In the case of the thinnest bar, however, the magnetizing power varied between the limits 1 and 11; and the maximum value of the power in this case was twice as great as that applied by Müller.

The law of proportionality between the electro-magnetic force and the strength of the current appears to be thus established, at least for the case where the cores are formed from good, soft wrought-iron, and are free from coercive force; and finally, as of course it will be understood, within the limits of the magnetizing forces and dimensions of cores above stated—that is to say, in all cases where the question possesses practical importance.

This consequence has been recently assented to by Müller(2), inasmuch as he observes that by means of the formula of interpolation deduced from his observations, the results of Buff and Zamminer might be determined beforehand.

In the case of thin bars, however, Müller(3) always observes striking divergences from the law of proportionality. It is quite possible that these, as well as similar results communicated by Feilitzsch(4), are to be referred to the fact that the law of proportionality does not hold good for thin cylinders. All such experiments, however, lack the power of proof, as long as we do not possess the means of determining the developed magnetism, independent of the influence of coercive force.

(1) Ann. Ch. Pharm. LXXV, 83; Phil. Mag. [4] I, 194 (in abstr.)

(2) Pogg. Ann. LXXXII, 182.

(3) Bericht über die Neuesten Fortschritte der Physik, 501; Pogg. Ann. LXXXII, 181.

(4) Pogg. Ann. LXXX, 321.

Action at a distance.

In the inquiry just mentioned, Feilitzsch, in addition to the ratio of the magnetic force to the strength of the current, has also examined the influence of the thickness of the iron cylinder. From his experiments, it follows that when the thickness decreases, the magnetic moment diminishes more slowly than the diameter. A series of interesting experiments which he made with hollow cylinders placed one within the other, gave the key to this department, which however was already known. These experiments proved that the magnetism did not remain at the surface alone, but according as the magnetizing force was increased, penetrated more and more into the interior of the soft iron, and farther, that each layer of the soft iron had a point of saturation. The facts certainly corroborate the assertion of Müller, that iron possesses a point of magnetic saturation. They cannot however be urged unconditionally against the general truth of the law, according to which the force of the electro-magnet increases in the same ratio as the strength of the current; for it cannot be asserted that the capacity of iron to assume the magnetic state is limited, as long as it is believed possible to increase without limit the current passing through the coil.

The magnetic force of electric spirals has been made the subject of a theoretical investigation by Feilitzsch(1); he has been conducted to the result that when spirals of the same length, but of unequal widths, are made use of, the exterior action, when the same strength of current is applied, is proportional to the square of the radius of the coil. Were this proposition true, it must hold good for every single coil. It is known, however, that the action of a circular current upon a magnetic needle, the distance of the centre of the circle from the needle being given, attains a maximum when the circle has attained a certain diameter.

H. Schwarz of Breslau(2) describes an apparatus, not yet constructed, by means of which he considers the determination of time in magnetic observations will be facilitated. It consists essentially in the substitution of the sense of feeling for that of hearing. Perhaps when so modified that not only the times of observation, but the seconds in their successive passage, shall be rendered sensible to the feeling, the apparatus may be recommended to deaf observers.

Terrestrial Magnetism.—The western variation of the magnetic needle at the Observatory of Paris, on the 30th of November, 1849, one hour twenty-five minutes amounted to $20^{\circ} 34' 18''$. The inclination was $60^{\circ} 44'$. The annual decrease of the inclination $3'(3)$.

According to a report by Sabine(4) on the results of observations

(1) Pogg. Ann. LXXIX, 564.

(2) Pogg. Ann. LXXXI, 268.

(3) Arch. Ph. Nat. XIII, 138.

(4) Phil. Trans. for 1850, I, 201; Arch. Ph. Nat. XV, 46.

on terrestrial magnetism at Toronto, the horizontal force of the earth's magnetism from January 1845 to April 1847, possessed there a mean value of 3.53043, with a mean annual decrease of 0.0042. The inclination on the 1st of March, 1847, was $75^{\circ} 16' 09''$, with an annual increase of $0' 89''$.

Terrestrial
magnet-
ism.

Sabine(1) communicates the remarkable fact, that in Toronto (Canada) and Hobart Town (Van Dieman's Land)—two magnetic stations which are nearly at opposite points of the earth's surface—the total magnetic force from October to April inclusive, is greater than from April to August inclusive, and that the inclination-needle, in both places, stands more nearly perpendicular during the former period than during the latter.

W. A. Norton(2) develops a new theory of terrestrial magnetism, and endeavours to prove that the daily and yearly variations of the horizontal intensity are dependent on alterations of temperature and on the conditions of moisture at the earth's surface. He finds that these variations proceed in a manner exactly inverse to that of the regular barometric changes; that is, the maxima of the former coincide with the minima of the latter, and the reverse.

S. Beswick(3) explains a method of calculating the magnetic declination, which differs essentially from that of Gauss.

Magnetism of Steam.—R. Phillips(4) gives the continuation of a memoir on the magnetism of steam, touched upon in the former Report (p. 115).

With reference to the alteration of the conductivity of iron for heat when the metal is magnetized, see page 44.

Electro-Magnetic Engine.—Within a powerful spiral it is known that an iron bar will seek to set itself central, and if removed from this position will spring back to it. On this property of spirals, Page(5) has based the construction of an electro-magnetic engine. The iron core moves successively through several spirals, which are traversed one after the other by a current, and is caused to return in the same manner. In this way a motion to and fro is obtained which may be transmitted. By this means Page is said to have already constructed a machine of 10-horse power.

With reference to the investigation of electro-magnetism as a moving force, see page 53.

Action of the Magnet on Polarized Light.—Matteucci(6) has measured the rotation of the plane of polarization of a ray passing through

(1) Pogg. Ann. LXXIX, 478.

(2) Sill. Am. J. [2] VIII, 35, 216, 350; X, 330.

(3) Phil. Mag. [3] XXXV, 511; XXXVI, 183.

(4) Phil. Mag. [3] XXXVII, 283.

(5) Sill. Am. J. X, 243; Phil. Mag. [4] I, 161.

(6) Ann. Ch. Phys. [3] XXVIII, 493; Arch. Ph. Nat. XIV, 37; Ann. Ch. Pharm. LXXVI, 197 (in abstr.)

Action of
the magnet
on polar-
ized light.

Faraday's heavy glass and through crown or flint-glass, when the bodies were compressed or their temperature varied, the rotation being effected by means of an apparatus of Rhumkorff.

When the analyzing Nichol was so placed that a double plate of Soleil showed a uniform tint, and the glasses were moderately compressed, by turning the Nichol through a certain angle, the same tint could be restored. The electro-magnet acted differently upon the compressed glass and upon the glass before compression; the rotation was more considerable when it acted in the same direction as the compression than when it acted in an opposite direction. Matteucci believes that the following general rule may be deduced from his experiments :

When the rotation consequent upon compression is considerably greater than that due to the action of the magnet alone, the maximum action of the latter after compression, and in the same direction as that of the compression, is equal to the action of the magnet alone, or it is greater. When, on the contrary, the action of compression is less than that of the magnet by itself, the latter produces a less effect after than before compression.—Matteucci also imagines that the action of the magnet on the compressed glass attains its maximum value after a somewhat longer time than when the glass is not compressed.

The influence of temperature may be seen from the following experiment. Faraday's heavy glass, at an ordinary temperature, showed a rotation of 6° , which rose to 8° when the glass, immediately before the experiment, was dipped into boiling oil. Upon cooling, the rotation sunk to its former value.

Matteucci finally examined whether the nodal lines on a vibrating iron plate suffered any alteration when the plate was subjected to the action of a very powerful electro-magnet. Not the least alteration was observed.

Theory of Diamagnetism.—V. Pierre(1) communicates theoretical considerations and mathematical developments on the reciprocal action of a body under the influence of a magnetic-pole and the medium which surrounds the body. The object of the investigation is to bring magnetic and diamagnetic phenomena under a common point of view, so that the assumption of a single force, the magnetic, shall be sufficient to explain all. Pierre endeavours to prove that besides depending on the strength of the magnet and the mutual distances, the character of the phenomena is influenced in a particular manner by the ratio of the coercive forces of the bodies examined to those of the surrounding medium. The following are his chief results: Let M denote the quantity of free magnetism developed at any point C

of a body; X , Y , Z , the components of the total action of the magnetic forces upon the point C in the direction of the axes of co-ordinates; the following phenomena are then possible: *a.* The body has small coercive force, and M always the sign opposite to that of the pole P . X , Y , Z , are attractive forces. Under this head are to be classed the phenomena of real magnetic bodies. *b.* P and M having opposite signs, within a given space around P attraction takes place, beyond this space repulsion. *c.* At all distances, attraction; if the sign of M changes. *d.* Repulsion at small distances, attraction at greater distances, and the reverse, simply by changing the sign of M . *e.* At smaller distances, from P repulsion, at greater distances attraction, where P and M always have the same sign. These are the phenomena which have been hitherto named diamagnetic, and it is a necessary requirement that the body should possess a greater coercive force than the surrounding medium.

De la Rive(1) gives a review of the discoveries hitherto made in the domain of diamagnetism, and of the action of a magnet in causing the rotation of the plane of polarisation of light. With regard to the origin of the latter phenomenon, he proposes a new hypothesis. Magnetism indeed acts upon the molecular state of magnetic bodies as demonstrated by the numerous experiments of Joule, Matthiesen and Matteucci; but there is nothing to justify the assumption that the molecular state of non-magnetic bodies is also changed by magnetism. Besides this, the power to cause the plane of polarization to rotate is also inherent in fluids, and is not changed when these bodies are set in motion or traversed by electric currents. The property in question cannot therefore be due to a peculiar molecular arrangement. Just as little is the luminiferous ether in its ordinary state affected by a magnet, inasmuch as the plane of polarization of a ray passing through a vacuum, or through air, is, according to Faraday, unchanged by the magnet. It remains, therefore, only to assume that the action of the magnet is exerted upon the condensed layers of ether which surround the molecules. A comparison of the capacities of rotation hitherto examined, proves indeed that this capacity increases with the refractive power of the substance.

Plücker(2) has given an interesting review of his entire labours in the domain of diamagnetism; the results have been already described singly in these Reports(3).

On Diamagnetic Repulsion.—W. Thomson(4) communicates the results of a mathematical inquiry regarding the forces excited in

(1) Arch. Ph. Nat. XIII, 107.

(2) Ann. Ch. Phys. [3] XXIX, 129.

(3) Annual Report for 1847 and 1848, I, 192, 193, 195, 197, 200; Annual Report for 1849, III, 121, 122, 125, 126.

(4) Phil. Mag. [3] XXXVII, 241; Pogg. Ann. LXXXII, 245; Instit. 1850, 365.

On dia-
magnetic
repulsion.

uncrystallized magnetic and diamagnetic bodies under the influence of the poles of a magnet. According to Thomson, a little sphere would be driven in the direction in which the magnetic force increases or decreases most speedily, according as the sphere is magnetic or diamagnetic. The direction of motion does not always coincide with that of the magnetic lines of force, but may also be perpendicular to the latter, as in the case of small spheres of bismuth or of iron suspended midway between the poles of a horse-shoe magnet, and a little to the side of the line which joins the poles.—The motion of magnetic bodies exhibits itself chiefly as attractive, inasmuch as the places of strongest magnetic force are, in general, nearest to the magnet.—Thomson farther finds that a sphere of magnetic or unmagnetic substance, in the neighbourhood of a magnet, and subjected solely to its action, can only be in a position of equilibrium where the magnetic force is either a maximum or a minimum. A *stable equilibrium* is only possible for a *diamagnetic* substance at the absolute minimum point. The point of absolute maximum lies within the magnet itself, so that for a magnetic sphere a position of stable equilibrium without the magnet has no existence.—Finally, Thomson makes some remarks on the proposition of Plücker, which assumes that diamagnetic repulsion decreases more quickly than magnetic attraction, when the distance between the body and the magnet is increased, or when the exciting current is diminished. Thomson is inclined to explain the phenomena in question by assuming that in the vicinity of the magnet, or when strong currents are applied, the magnetic induction does not increase in the same ratio with its exciting cause, but in a less ratio; while the *more* feeble diamagnetic induction preserves the proportionality. Thomson's own experiments on this subject offer nothing new.

Quantitative Determinations of the Magnetic and Diamagnetic Forces.—From the investigations of E. Becquerel(1), mentioned in the Report of last year, and which now lie more completely before us, we will communicate some results which are independent of the peculiar inferences(2) which Becquerel believed might be deduced from them.—The diamagnetic repulsion of a long series of bodies was determined by the torsion of a silver wire. Becquerel found that with currents of different strengths the repulsion was proportional to the square of the strength. By examining little bars of diamagnetic substances—for example, of sulphur or wax—first in the air, then in different saline solutions and other fluids, and comparing the results, he was able to infer the intensity of the repulsion which a mass of fluid of the form and volume of the little bars would endure. Referred to equal volumes and to the unit of force of the

(1) Ann. Ch. Phys. [3] XXVIII, 283; Ann. Ch. Pharm. LXXVI, 199 (in abstr.)

(2) See Annual Report for 1849, III, 126.

current, and assuming the action upon water to be = 10, the following results were obtained; the repulsion is denoted by the sign —, and attraction by the sign +:

Quantitative determinations of the magnetic and diamagnetic forces.

Substances.	Magnetic action.	Substances.	Density.	Magnetic action.
Water . . .	— 10	Common spirits of wine . . .	0.8059	— 8.50
Glass . . .	+ 7.92	Rectified alcohol . . .	0.8059	— 7.69
Sulphur . . .	— 10.68	Bisulphide of carbon . . .	1.2767	+ 13.30
Phosphorus . . .	— 16.39	Solution of protochloride of iron, No. 1.	1.2767	+ 360.70
Selenium . . .	— 16.52	" " " " No. 2.	1.4334	+ 658.13
Lead . . .	— 15.28	" " " " No. 3.	1.0695	+ 91.93
Bismuth . . .	— 217.61	Solution of chloride of magnesium . . .	1.3197	— 12.17
Zinc . . .	— 2.5	Solution of chloride of sodium, No. 1.	1.2084	— 11.28
Wax . . .	— 5.68	" " " " No. 2.	1.1728	— 10.75
		Solution of chloride of calcium . . .	1.161	— 11.61
		Solution of sulphate of nickel . . .	1.0827	+ 21.28
		Commercial sulphate of copper . . .	1.1265	+ 8.14
		Protosulphate of iron . . .	1.1923	+ 31.15
		" " " " . . .	1.1728	+ 180.22
		Persulphate of iron . . .	1.1587	+ 135.16

In order to compare the magnetic action of the various substances mentioned in this table with that of iron, Becquerel formed little bars from a mixture of wax and iron filings, which had been previously heated to redness in a current of hydrogen—as with massive iron bars it is known that the induction is not proportional to the mass. By the method of oscillations, Becquerel compared this bar with the solution of protochloride of iron, No. 2, enclosed in a glass tube, and found as the mean of several experiments the following ratios of the magnetic forces:

	for equal volumes.	for equal weights.
Iron	+ 1000000	+ 1000000
Solution of protochloride of iron (sp. gr. 1.4334) . . .	+ 25.7	+ 140
Water	— 0.4	— 3

Becquerel sought to determine the magnetic force of gases from the difference of repulsion exhibited by the same body *in vacuo* and in the gas under examination. Oxygen alone proved itself strongly magnetic; in experiments with little pieces of charcoal which absorbed a large quantity of oxygen it was found that the charcoal, in consequence of the absorption, was strongly attracted in oxygen gas, while *in vacuo* it was repelled. Carbonic acid and nitrous oxide, which are still more plentifully absorbed by charcoal, exhibited a weak repulsion. A comparison of oxygen, air and water, yielded as the mean of several experiments the following results:

	Density.	Specific Magnetism.	
		for equal volumes.	for equal weights.
Oxygen at a pressure of 0 ^m .76 . . .	0.001432	+ 1.80	+ 1257
Air	0.001299	+ 0.38	+ 293
Water	1.000000	— 10.00	— 10

Quantita-
tive deter-
minations
of the
magnetic
and dia-
magnetic
forces.

and a comparison with iron gives for the specific magnetism for equal weights :

Iron	+	1000000
Oxygen	+	377
Air	+	88

Becquerel calculates from this, that a cubic metre of oxygen must be brought to the same volume as that occupied by 5.5 decigrms. of iron in order to possess the same magnetic force as iron; farther, that the atmosphere possesses a magnetic power equal to that of a shell of iron $\frac{1}{10}$ of a millimetre in thickness encompassing the whole earth.

Finally, Becquerel has considered it interesting to compare the capacity of optical rotation attained *in vacuo* by various substances under the influence of the magnet with the specific magnetism of the substances for equal volumes. He infers from his experiments that the stronger the repulsion of the substance examined by the magnet, the greater is its power of optical rotation; while with substances which, in the air, are attracted by the magnet, both forces increase inversely, without however following a simple ratio.

In a later investigation, E. Becquerel(1) has made some additions to the foregoing results. By the above method, he found: 1. That the repulsion of diamagnetic substances, as bismuth, lead, sulphur, wax, water, &c., is proportional to the square of the strength of the electro-magnet, and that these substances do not assume a permanent polarity. 2. That a number of magnetic substances behave like soft iron—that is, their attraction is proportional to the square of the strength of the magnet, and they assume no permanent polarity. 3. That, on the contrary, with many substances which are attracted by the magnet, as platinum and some compounds of iron, the law of proportionality to the square of the current first exhibits itself when the currents are powerful, while with weaker intensities the ratio is a different one, and also changeable. All these substances, though in a less degree than steel, appeared capable of assuming a permanent polarity. 4. Many compound substances, as glass and charcoal, are attracted when the power of the electro-magnet is feeble, but repelled when the power is high; and they also assume a permanent polarity. Becquerel regards them as mixtures of the bodies mentioned under 1. and 3.—What Becquerel communicates regarding gases contains nothing essentially new. He has succeeded in proving that small glass tubes, which are repelled when empty, are attracted when filled with condensed oxygen.—Becquerel still adheres to his former improbable hypothesis regarding the nature of diamagnetism(2).

(1) Compt. Rend. XXXI, 198; Instit. 1850, 258.

(2) Annual Report for 1849, III, 126.

Diamagnetism of Gases.—Of a new investigation of Faraday(1), the method alone according to which he has examined the diamagnetic properties and intensities of gases is as yet made known. To a silk fibre a small bar was attached horizontally, and at the end of the latter another transverse bar was fixed: on this two equal spheres of thin glass were suspended symmetrically, equally distant from the axial line of a magnet and from each other: the spheres might be filled with different gases in any required state of rarefaction. The magnetic condition of the glass-shell and the air displaced exerted no influence, on account of the perfect symmetry. Oxygen gas drove every other gas out of the magnetic field. Compared with that of nitrogen; this force was very strong, when both gases possessed the same density; it decreased, however, when the density of the oxygen was lessened. The oxygen vacuum—that is, a vacuum which had been previously filled with oxygen—held the nitrogen in equilibrium. A greater or less condensation of the nitrogen, as well as of other gases (olefiant gas and cyanogen excepted), had no influence upon the position of the torsion balance.

On Diamagnetic Polarity.—By the experiments of Reich, Weber(2), Poggenorff and Plücker(3), it appeared to be proved that diamagnetic bodies, when excited by an electro-magnet, assume a polarity of such a kind that the induced pole is of the same name as the inducing one. Faraday(4) has shown, in a series of experiments, that this polarity is caused by momentary currents induced in the mass, and is not due to the magnetization of the particles.—At the end of the iron core of a strong electro-magnet, Faraday placed an induction spiral, embracing 516 feet of copper-wire, which protruded 2 inches beyond the end of the magnet, and possessed an interior diameter of 1 inch, and an exterior diameter of 2 inches. In the hollow space, cores of various substances, most of which were $5\frac{1}{2}$ inches in length, and $\frac{3}{4}$ of an inch in diameter, could be moved to and fro, for a distance of 2 inches, several times in a second. The motion was effected by a winch and lever arrangement, and was such that at the end of the motion the cores were nearly in contact with the magnet. The two ends of the spiral were connected with a delicate galvanometer, and a commutator was introduced, which could be so governed that the inductive actions consequent upon the motion either supported each other or neutralized each other, partially or totally. This apparatus appears, however, to furnish a less delicate means of testing the magnetic excitation than an astatic needle; and several precautions, fully described by Faraday, were necessary to

(1) Phil. Mag. [3] XXXVII, 545; Instit. 1851, 32.

(2) Annual Report for 1847 and 1848, III, 200.

(3) Ibid.

(4) Phil. Trans. for 1850, Part I, 171; Phil. Mag. [3] XXXVII, 88; Sill. Am. J. [2] X, 188; Pogg. Ann. LXXXII, 75, 232; Ann. Ch. Pharm. LXXVI, 213 (in abstr.)

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exclude all sources of illusion. The residual magnetism of the core might, in particular, readily give occasion to error.

With a solution of sulphate of iron in a glass tube, Faraday obtained no action, and the same result was obtained with a cylinder of magnetic glass; a tube filled with small crystals of sulphate of iron, or large pieces of the crystal, produced deflections of 2° ; red sesquioxide of iron acted but feebly, thin iron-wire very powerfully. Nickel and cobalt deflected the needle in the same direction as iron, while diamagnetic substances produced a deflection in the opposite direction. Bismuth, antimony and phosphorus, however, showed scarcely any action; while the better-conducting metals, copper, silver, gold, produced deflections of 60° or 70° .—In order to prove, in a more certain manner, that this action is due solely to the induced currents excited in the mass, Faraday showed that the action of the copper core was scarcely diminished when its length was reduced from $5\frac{1}{2}$ inches to 2 inches, while that of a core of iron was considerably weakened by shortening. Copper-turnings, or bundles of copper-wire, were without effect; a core of thin copper-discs, a gold core formed of sovereigns, a silver core formed of sixpenny-pieces, acted powerfully. There was no decrease of action observed in the case of iron, when a bundle of thin wires was substituted for the massive cylinder.

Abstracting from the resistance in the spiral and in the galvanometer, an iron core must act equally strong by quick or slow motion, inasmuch as the same quantity of electricity is always set in action. The quantity of electricity excited in diamagnetic bodies also remains the same when the velocity is changed; but the maximum of the intensity of the current, and with it the action on the galvanometer, must increase. In the case of iron, when the velocity was increased in the ratio of 1 : 10, no change was observed on the galvanometer; with the copper core, the deflection increased from 21° to 80° , when the velocity was increased in the ratio of 1 : 6.

With regard to the extremely ingenious arguments in favour of the difference of excitation in magnetic and diamagnetic bodies, deduced by Faraday, from the circumstance that in both cases the maximum effect on the galvanometer was obtained by two totally different arrangements of the commutator, we must refer to the memoir itself.

Faraday refers the phenomena observed with the diamagnetic cores, and the revulsions observed with antimony, and described in a former paper(1), to the same origin. A square block of copper, of $\frac{1}{2}$ an inch the side, and $\frac{1}{4}$ of an inch thickness, was formed of 72 layers of thin sheet-copper folded together, and suspended from a silk thread, between the poles of an electro-magnet; so that the block of copper formed an angle of 30° with the equatorial line. When the

magnet was excited, the block went forward to 50° , stood still there, and when the current was interrupted, passed through the equatorial line to 60° at the other side; then returned through the equator, and assumed an almost axial position. The revulsion, says Faraday, in explanation of this beautiful experiment, arises from the excitation of induced currents in the mass of copper during the decrease of the magnetism of the iron core, the axis of the induced currents endeavouring to set itself parallel to the magnetic axis. The high conductive capacity of copper, and its separation into leaves, permits these currents to be formed so readily, and renders the time of vibration so short, that two or three oscillations may be executed before the force of the electro-magnet has sunk to its minimum. The influence of time on the increase and decrease of the magnetic force, is here exhibited in a peculiarly beautiful manner.

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With magne-crystalline cores, Faraday obtained no action which could justify a conclusion in favour of polarity; the action of ordinary magnetism alone exhibited itself in the case of crystals of sulphate of iron.

The question whether the different cores acted immediately upon the spirals, or first upon the magnet, and then the latter upon the spirals, Faraday imagines must be decided in favour of the latter supposition; for the action of an iron-wire, or of a core of silver or copper, remains quite the same when a copper sheathing, or a sheath of glass or of air, is introduced between it and the spiral. Faraday remarks, in conclusion, that he has not succeeded in obtaining the result of Weber, which purported to prove the polarity of diamagnetic bodies. The experiment of Plücker, according to which a piece of bismuth obtains a stronger directive force when a small bar of iron is placed in the equatorial plane, Faraday refers to an alteration of the lines of force—that is, to a local change of the intensity of the magnetic field.

Magnetic Deportment of Crystals.—Knoblauch and Tyndall⁽¹⁾ have engaged in an investigation of the real cause to which the directive force of crystals discovered by Plücker is to be referred. In the first place, they have found that the relation between the optical and magnetical nature of crystals, assumed by the latter investigator, and according to which the axes of negative crystals are repelled, and those of positive crystals attracted by the poles of a magnet, is unsupported by experiment. Of 11 circular discs of calcareous spar, all of which were cut parallel to the axis of the crystal, five set their axes equatorial and the remaining six as constantly axial. By the substitution of a portion of isomorphous

(1) Pogg. Ann. LXXIX, 233; LXXI, 481; Phil. Mag. [3] XXXVI, 178; XXXVII, 1; Arch. Ph. Nat. XIII, 219; Sill. Am. J. [2] IX, 114; X, 393; Instit. 1850, 325; De la Rive's Report, Arch. Ph. Nat. XVI, 177.

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carbonate of iron the mass of the latter was rendered magnetic, that of the former was diamagnetic; but all the crystals were optically negative. Even with a complete rhomb of magnetic calc-spar the axis was attracted, although the form of the crystal acted against this. Rock crystal exhibits an extremely feeble magnetic action, and requires the greatest care in its purification and suspension; but the positive axis in ten specimens, where the needful precautions were taken, set constantly equatorial.—The middle-line of several optic biaxial crystals—for instance, of sulphate of zinc, sulphate of magnesia and a cube of dichroite—set axial; in others, on the contrary, as sulphate of nickel, borax and diopside, equatorial.—The middle-line of the optically positive crystals, heavy spar and celestine, set equatorial; also that of ferrocyanide of potassium (which Knoblauch and Tyndall, in opposition to its position in the crystallographic system, regard as biaxial), even when the diamagnetic crystal was considerably longer in the direction perpendicular to the middle-line. Topaz, on the contrary, set its middle-line axial.—Finally, Knoblauch and Tyndall found that crystals exhibited a directive action between the poles of a magnet, when neither the general magnetic nature of the mass, nor the axial force, could contribute to the effect. Thus, for example, where a cube of tourmaline, or beryl, was so suspended that its axis was vertical, or when a plate of calc-spar, cut perpendicular to the axis of the crystal, was made use of.—It is evident that the law of Plücker, mentioned above, cannot be reconciled with these experiments. Knoblauch and Tyndall, therefore, conclude that the phenomena must be explained on other grounds, which grounds suggested themselves during their observations. They found that the same direction which, in purely diamagnetic bodies, set equatorial, in magnetic bodies of a precisely similar structure set axial. For the explanation of all the phenomena exhibited by crystals in the magnetic field, the above investigators deem it sufficient to assume a difference of magnetic action in different directions through the mass. With ivory, which is unequally diamagnetic in different directions, and with gutta-percha, whose magnetic action was also different in different directions, the entire phenomena exhibited by diamagnetic and magnetic crystals were imitated in the most perfect manner, and hence the conclusion arrived at by Knoblauch and Tyndall, that these phenomena are to be referred solely to the peculiar aggregation of the material particles—a conclusion which was farther established by observations on pseudomorphoses, and by a series of experiments with substances artificially prepared. We will here adduce only a few of the latter. From flour, which is diamagnetic, by the addition of a little gum-water a bar was formed, whose length set equatorial between the poles. When the bar was compressed to the form of a cube, and the pressure continued until it was reduced

to a thin plate, the disc thus formed behaved exactly like a magnetic body, and took up the axial position. From this it was manifest that in the direction of compression the diamagnetic force was increased. An uncompressed cube of the same substance exhibited no directive power. When powdered carbonate of iron was mixed with the flour the whole phenomena became reversed. A paste was formed of powdered calcareous spar, and compressed in one direction; from the mass a rhomb was taken whose axis coincided with the line of compression; the model thus formed possessed all the magne-crystalline properties of a crystal of calcareous spar.—Even the more complicated phenomena exhibited by heavy spar, the diamagnetic action of which is greater along the shorter diagonal than parallel to the axis, and greater along the axis than parallel to the long diagonal, could be completely imitated by models. For this purpose, it was only necessary to form a dough from powdered bismuth, and to press this unequally in two directions at right angles to each other; then to form a rhombic prism from the mass, the short diagonal of which corresponded with the direction of strongest compression, and the axis with that of less compression.

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crystals.

Plücker(1), in a later investigation, has admitted that the law of action given by him regarding connection between the optical and magnetical deportment of crystals is not generally valid. He observes, that the view which connects the magne-crystalline phenomena with cohesion is not new to him; but that instead of referring the phenomena to a magnetization of the ultimate particles of the crystals, as done by Knoblauch and Tyndall, he assumes an unequal magnetic activity on the part of the ether in different directions.

In connection with Beer, Plücker(2) has undertaken a very elaborate investigation of the optical and magnetical deportment of crystallized bodies. On account of our limited space, we can here give only a general view of the results, and must refer to the memoir itself for information regarding the able and ingenious manner in which the experiments were carried out. In optical respects also the inquiry possesses great interest.

I. Crystals of the quadratic system.

Crystals.	Optical character.	General magnetic character.	Optic Axis.
Sulphate of nickel . . .	—	Magnetic	Repelled.
Molybdate of lead . . .	—	Diamagnetic	"
Vesuvian . . .	—	Magnetic	"
Arsenate of potassa . . .	—	Diamagnetic	No action.
Zircon . . .	+	"	Attracted.
Ferrocyanide of potassium . . .	+	"	No action.
Acetate of lime and copper . . .	+	Magnetic	Attracted.
Mellite (honeystone) . . .	—	Diamagnetic	"

(1) Pogg. Ann. LXXXI, 115—27.

(2) Pogg. Ann. LXXXI, 128; LXXXII, 42.

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ment of
crystals.

Uranium-mica, although optically negative, set its axis along the line which united the poles; the optically negative scapolite exhibited, as regards the direction of its axis, no distinct magnetic action.

II. Crystals of the hexagonal system.

Crystals.	Optical character.	General magnetic character.	Optic Axis.
Tourmaline	—	Magnetic	Repelled.
Pure calc-spar	—	Diamagnetic	"
Nitrate of soda	—	"	"
Beryl	—	Magnetic	"
Arsenide of lead	—	Diamagnetic	"
Diopase	—	Magnetic	"
Bismuth	—	Diamagnetic	Attracted.
Antimony	—	"	"
Arsenic	—	Magnetic	"
Ice	+	Diamagnetic	"
Sulphate of potassa.	+		Repelled.

Of crystals of calcareous spar, whose entire mass was magnetic, Plücker states that he has found some whose axes were attracted, and others whose axes were repelled. In quartz, Plücker and Beer have been unable to detect any directive action.

III. Crystals of the rhombic system.

In order to characterize the crystals of this system magnetically, Plücker and Beer denote the direction of the axis of the prism and of the short and long diagonals by a , b and c . They distinguish the following cases:

A.								B.			
When the suspension is in the direction of:								Repulsion of the axes.		Attraction of the axes.	
$a \mid b \mid c \mid a \mid b \mid c$											
set											
No.	equatorial			axial				Middle line.	Plane of axes.	Middle line.	Plane of axes.
1	b	a	a	c	c	b		a	ab	c	bc
2	c	a	a	b	c	b		a	ac	b	bc
3	b	a	b	c	c	a		b	ab	c	ac
4	b	c	b	c	a	a		b	bc	a	ac
5	c	c	a	b	a	b		c	ac	b	ab
6	c	c	b	b	a	a		c	bc	a	ab

Plücker and Beer refer these phenomena to the attraction or repulsion of two magnetic axes of equal values, and therefore assume the existence of the 12 cases under the head *B*. When the middle line possesses the tendency to set axial, Plücker and Beer name the crystals *magnetically positive*; in the opposite case, *magnetically negative*.—The following crystals of this system were particularly examined:

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ment of
crystals.

Crystals.	Optical character.	General magnetic character.	Magnetic action of the axes.
Citric acid	?	Diamagnetic	— No. 4.
Arragonite	—	"	— No. 1.
Tartrate of soda and potassa	+	"	+ No. 3.
Anhydrite	+	"	— No. 6.
Topaz	+	"	neutral.
Staurolite	+	Magnetic	+ No. 1.
Sulphate of nickel	—	"	+ No. 5.
" " zinc	—	Diamagnetic	+ No. 1.
" " magnesia	—	Magnetic	+ uniaxial.
Chromate of magnesia	—	"	neutral.
Sulphate of potassa	+	Diamagnetic	"

IV. Crystals of the clinorhombic (monoclinometric) system.

As fundamental form of these crystals, we can assume a rhombic prism oblique to either the long or the short diagonal. The plane passing through the axis of the prism and the diagonal inclined to the axis is the plane of symmetry (S), and perpendicular to it stands the orthodiagonal; let every plane passing through the latter be denoted by N , with the exception of the base which contains the long and short diagonals, and which we shall call B .—Let μ , ν , and π denote the axes of greatest, mean, and least elasticity of the luminiferous ether.

A. The optic axes lie in the plane of symmetry.

The orthodiagonal coincides with the axis of elasticity ν .

Crystals.	Optical character.	General magnetic character.	Magnetic action of the axes.
Protosulphate of iron	neutral	Magnetic	+ uniaxial (μ)
Succinic acid	neutral	Diamagnetic	— uniaxial (μ)
Ferricyanide of potassium	+	Magnetic	— (N)
Diopside	+	"	— (S)
Acetate of copper	+	" *	— (B)
Acetate of lead	+	Diamagnetic	—

B. The optic axes lie in the plane N , which is perpendicular to the plane of symmetry.

Crystals.	Optical character.	General magnetic character.	Magnetic action of the axes.
Hyposulphite of soda	+	Diamagnetic	+ (S)
Borax	—	"	+ uniaxial.
Acetate of soda	—	"	— uni or biaxial (as yet undecided).

* The crystals which have this sign attached are most probably magnetic, through the admixture of iron.

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deport-
ment of
crystals.

V. Crystals of the triclinometric system.

Crystals.	Optical character.	General magnetic character.	Magnetic action of the axes.
Cyanite	+ (Brewster)	Magnetic and diamagnetic specimens	+
Sulphate of copper	—	Magnetic*	+
Bichromate of potassa	+	„	„

* See Note, p. 157.

Even under the influence of terrestrial magnetism, as also that of an electric current, cyanite exhibited a directive action. Plücker showed how the presence of twin-crystals in this case might be detected by means of the magnet.

The magnetic action of bichromate of potassa was peculiarly complicated, and it was not possible to refer its phenomena to the action of two magnetic axes of equal values.

C. Brunner(1) has shown that a piece of ice sets equatorial between the magnetic poles, and that it is also diamagnetic.

Electricity. Electric Machine.—Barlow(2) describes a new electric machine, the peculiarity of which consists in the circumstance that the glass disc is superseded by a plate of gutta-percha.

Münch(3), in Strasburg, states that to render electrifying discs active in moist weather, it is only necessary to draw on both sides a light streak of tallow from the centre to the rim. Glass feet are also said to be rendered more insulating when coated with a little tallow, the latter being afterwards rubbed away by linen.

Electrometry.—Marié Davy(4) has made experiments with the view of determining the degree of confidence which may be placed in the torsion-balance as an instrument of measurement. He also investigates the conditions under which the torsion-balance can furnish exact indications.—The earlier labours of Riess(5) in connection with this subject are rendered neither dispensable nor more complete by this investigation.

E. Roche(6) has attempted to determine by the formula of Poisson the electric density at the two extreme points of the common diameter of two opposed spheres as function of the distance, without however arriving at a general expression.

(1) Pogg. Ann. LXXIX, 173.

(2) Phil. Mag. [3] XXXVII, 428.

(3) Compt. Rend. XXX, 47; Instit. 1850, 26.

(4) Compt. Rend. XXXI, 863; Instit. 1850, 409.

(5) See Annual Report for 1847 and 1848, I, 206.

(6) Compt. Rend. XXXI, 651.

Spark-Micrometer.—Marié Davy(1) gives notice that through experiments with electricity of high tension, he has arrived at the conclusion that the *spark-micrometer* of Riess(2) is an instrument by means of which the density of the electric fluid may be determined.

Spark-mi-
crometer.

Discharging Current of the Electric Battery.—In a paper on the mechanism of the electric discharge(3) which was noticed in the former Report(4), Riess makes a distinction between the continuous discharge of the electric battery which proceeds from one section to the other when the connection is perfect, and the discontinuous, in which the electric fluid stops at a certain section, acts by influence upon a section at a distance, and afterwards suddenly breaks through the intervening bad conducting portion of the circuit in the form of a spark. When the discharge is effected by a condenser, Riess has observed(5) that the action of the discharging current in the interrupted portion of the circuit between both plates is so perfectly similar to the actions observed when the circuit is complete and the discharge continuous, that in both cases the same mechanism of discharge may be assumed. Let the two plates of the condenser be imagined to be brought infinitely near to each other, the discharge then passes into that which takes place when the arc is continuous. When, on the contrary, two plates are fixed at a finite distance apart and the density of the electricity in the battery is heightened, so that the space between the plates is broken through, the discontinuous discharge is obtained. It follows from this, that every discontinuous discharge is preceded by one with interrupted arch, in the latter of which, as long as it endures, an action similar to that of the continuous discharge takes place. To this circumstance Riess attributes certain coincidences in the laws of both forms of discharge.

J. H. Lane(6), of Washington, describes a method of discharging the Leyden battery, the striking effects of which were exhibited in public lectures by a Mr. Baggs, at the Polytechnic Institution, in London. It is distinguished from the discharge *par cascade*(7) by the circumstance that the jars are charged in the ordinary way, then insulated and connected *par cascade*. The discharge follows on uniting the knob of the first jar with the exterior surface of the last one.

The cascade-battery of Franklin does not, according to Riess(8), possess the practical value which has been ascribed to it. Although

(1) Compt. Rend. XXX, 323.

(2) Pogg. Ann. XL, 332; LIII, 4.

(3) Pogg. Ann. LXXVIII, 433.

(4) Annual Report for 1849, III, 124.

(5) Berl. Acad. Ber. 1850, 130; Pogg. Ann. LXXX, 214; Instit. 1850, 302.

(6) Sill. Am. J. [2] VII, 418.

(7) See Annual Report for 1847 and 1849, I, 210.

(8) Pogg. Ann. LXXX, 349.

is charged
current
the elec-
tric bat-
tery.

the first jar only is immediately charged from the conductor, when strong charges are desired this requires more time and a much greater activity on the part of the machine than when the jars are charged directly to the same degree.

This department which, as Riess observes, did not escape the notice of Franklin himself, has the following origin. A Leyden jar receives electricity on its interior until its knob has attained a determinate electric density. The quantity of electricity thus received is very small when the exterior coating of the jar is insulated, increases in proportion to the length of a wire laid against the exterior coating, and attains its maximum when the wire is connected with the earth. It follows from this, that for a definite quantity of electricity within the jar the density on its knob will increase according as the conduction from the exterior surface is diminished. In the battery of Franklin, the conduction from the first jar decreases in proportion to the number of jars connected together. Hence the greater this number, the less complete will be the charge capable of being imparted by a definite degree of power on the part of the machine, and for constant charges—measured for instance by Lanc's jar—the greater will be the density of the electricity on the knob of the first element of the battery. If therefore such a battery consisting of four elements be charged, but only three elements made use of in the discharge *par cascade*(1), the connecting-wire being placed upon the exterior surface a_3 of the third jar, the fourth element having been previously discharged alone, and by this means a perfect conduction from the exterior coating a_3 to the earth effected, the density on the knob i_1 of the first element sinks immediately. Hence a shorter discharging distance must be observed than if the connecting-wire had been united with a_1 .

For the same reason the discharging distance must be still smaller when the connecting-wire is laid on a_2 and finally on a_1 . It might be imagined that a general law for this decrease of the discharging distance is discoverable in the case where all the elements of the battery are similar and of the same size, and all the insulating stools and connecting-wires equal. Riess, however, concludes from a series of experiments made with the view of answering this question, that the discharging distance as well as the heating of the connecting-wires of a cascade-battery consisting of equal elements, does not depend alone upon the number of the elements made use of, but also on their form, absolute size, the nature of the insulating stools, and the length and form of the intervening wires. The laws deduced by Dove from his experiments with the cascade-battery(2) as also the explanation formerly given by Riess(3) himself, is according

(1) See Annual Report for 1847 and 1848, I, 210.

(2) Ibid.

(3) Annual Report for 1849, 134.

to the foregoing, only valid for the peculiar form of apparatus applied in each particular case.

Inducing Effect of the Discharging Current.—Riess(1) has assured himself that two portions of the connecting wire of the battery brought close together, act upon each other. The discharging current is weakened by this action when it traverses both portions in the same direction, and strengthened when its directions in both portions are opposed to each other. The nature of this action, therefore, quite coincides with the inducing influence of other electric currents. The experiment on which this result is based was conducted in the following manner: two plane wire spirals (each embracing 31 coils of a wire $53\frac{1}{2}$ feet in length) and a delicate air-thermometer were placed in the circuit. When the spirals were $\frac{1}{10}$ inch apart and parallel to each other, the heating of the air-thermometer increased or decreased by a small quantity, according as the current traversed the spirals in opposite or in similar directions. When the spirals were placed wider apart, so that the induction was not sensible, the heating observed was greater than in the one and less than in the other of the cases above mentioned.

Inducing effect of the discharging current.

The Leyden battery and its discharging current have been made the subjects of the following memoirs by Knochenhauer:

On the relations of the by-currents of the electric battery when the circuit is divided into branches(2).

On the correction of observations with an electrical battery composed of unequal jars(3).

Luminous Brushes.—By means of a bent metallic wire, the thickness of which is a matter of indifference, and both ends of which were fastened to the conductor of an electric machine, J. Löwe(4) has obtained electric brushes of peculiar beauty. The phenomena were exhibited most splendidly when a pasteboard cylinder, coated with tin-foil, was moved to and fro in the space included by the wire.

Intensity of the Spark.—A. Masson(5) assumes as the result of numerous photometric observations made by him, that the luminous intensity of the electric spark is inversely proportional to the resistance of the circuit. When several sparks were generated by discharging the battery through the same connecting wire, the intensity of the sparks was found to be proportional to the square of the quantity of electricity and to the electric tension at the moment of discharge.—In a continuation of this inquiry, of which notice is given(6), and which is more particularly devoted to the

(1) Pogg. Ann. LXXXI, 428.

(2) Pogg. Ann. LXXXIX, 255.

(3) Pogg. Ann. LXXXIX, 354.

(4) Pogg. Ann. LXXXIX, 573.

(5) Compt. Rend. XXX, 627; Arch. Ph. Nat. XIV, 134; Instit. 1850, 161; more in detail Ann. Ch. Phys. [3] XXX, 5.

(6) Compt. Rend. XXXI, 887; Instit. 1851, 3.

Atmo-
spheric
electricity.

study of the spectrum obtained from the electric light, the author expresses the belief that he has discovered the cause of the latter phenomenon.

Atmospheric Electricity.—W. R. Birt(1) has been engaged with inquiries regarding the connection of atmospheric electricity with the precipitation of vapour. R. Phillips(2) infers from his experiments on the development of electricity by the condensation of vapour a connection of this sort of electricity with lightning and the aurora.

Thunder-storms.—Opinions regarding the electricity of the clouds in thunder-storms have been communicated by Schönbein(3). Remarkable lightning-phenomena have been described by Joule(4), Clare(5), Phillips(6), Jomard(7), Göppert(8), and Grebel(9).

Lightning Conductors.—According to a decision of the French Academy(10), based upon experience, the protective power of a lightning conductor extends through a sphere, the radius of which does not exceed twice its height. E. Loomis(11), in New York, describes a case in which a conductor, made according to order, and in good condition, was insufficient to extend protection to a distance equal to twice its height.

Electricity of Flame.—The peculiar electrical character of flame has been hitherto principally known from the experiments of Becquerel(12) and Pouillet(13).

Hankel(14) has lately proved it to be probable that the flame of spirit possesses an independent electro-motive power, in virtue of which it tends to send an electric current from the top of the flame to the bottom. By means of a multiplying galvanometer, as also by means of a condenser, he determined the direction of the current; the strength of the current increased with the liveliness of the combustion, but in the most favourable case, on account of the feeble conductive capacity of the flame, was extremely weak. By introducing a zinc and copper element into the circuit of the flame-current, he succeeded in obtaining an approximate notion of the electro-motive force of the flame. Between different points of the

(1) Phil. Mag. [3] XXXVI, 161; Report of the 19th Brit. Assoc. 113.

(2) Phil. Mag. [3] XXXVI, 103, 303, 503.

(3) Arch. Ph. Nat. XV, 102.

(4) Phil. Mag. [3] XXXVII, 127.

(5) Phil. Mag. [3] XXXVII, 329.

(6) Instit. 1850, 348; comp. Martin's Instit. 1850, 359.

(7) Compt. Rend. XXXI, 8.

(8) Pogg. Ann. LXXXI, 467.

(9) Pogg. Ann. LXXXI, 577.

(10) Ann. Ch. Phys. [2] XXVI, 258.

(11) Sill. Am. J. [2] X, 320.

(12) Pogg. Ann. II, 202; XI, 437.

(13) Pogg. Ann. XI, 417.

(14) Pogg. Ann. LXXXI, 213.

flame, the electro-motive force was different, and partially dependent on the metallic tube by which the flame was surrounded. The current from the flame of a lamp burning freely could not be reversed by the current from an element of zinc and copper introduced into the circuit.—This was, however, effected by two elements of zinc and copper. The action of flame-electricity upon the needle of the galvanometer has also been observed by Henrici(1). He regards it as the consequence of a species of friction. To the same cause he thinks is to be assigned the current obtained when a red-hot and a cold platinum wire are simultaneously dipped into a fluid which conducts electricity.

Electricity
of flame.

Excitation of Electricity in Living Plants.—Pouillet imagined that he had discovered long ago(2) an excitation of electricity in the process of vegetation. Riess(3) did not find his experiments confirmed, and thus the existence of this source of electricity became again doubtful. In growing plants, Becquerel(4) has recently observed various electric actions, and ascribes them, in all cases, to a chemical origin.—Wartmann(5) has also discovered electric currents in all portions of fleshy plants, the strength of which increases with the vigour of growth and the quantity of sap possessed by the plant.—These currents form, in Becquerel's opinion, with which that of the Geneva physicist coincides, closed circuits within the plants. How it is that these currents can be conducted to the galvanometer independent of metallic contact is not stated.

Galvanic Battery.—Experiments with zinc and copper circuits, when a layer of moist earth was made use of as conductor, have been made by E. Loomies(6).

Gas Battery.—Osann(7) has remarked that gas batteries, in which the gases used have been obtained ^{fore} in electric decomposition, exhibited a stronger action than those ^{be} formed of gases obtained chemically.

Galvanometer.—W. S. Ward(8) has described a new form of balance-galvanometer. It consists of a two-legged coil of wire, which set perpendicularly on the ends of its wire, swings like a balance. The current is conducted through the points of support, which bear the wire ends, and which are insulated from each other. The poles of a horse-shoe magnet can be introduced at both sides of the point of support without interfering with the moderate vibrations of the coil. To both sides of the latter are attached suitable arms with

(1) Pogg. Ann. LXXIX, 170, 473.

(2) Pogg. Ann. XI, 430.

(3) Pogg. Ann. LXXIX, 288.

(4) Compt. Rend. XXXI, 633, Instit. 1850, 353; Ann. Ch. Phys. [3] XXXI, 40.

(5) Arch. Ph. Nat. XV, 301.

(6) Sill. Am. J. [2] IX, 2.

(7) Pogg. Ann. LXXIX 576.

(8) Chem. Soc. Qu. J. II, 26.

The law of
electro-
lysis incor-
rect?

scale-pans, in which weights are laid until the equilibrium, disturbed by the entrance of the current, is again restored.

On similar principles Becquerel and Wrede have already constructed galvanometric measuring-instruments(1).

The Law of Electrolysis incorrect?—It is a well-known fact, that in voltametric experiments the magnitude of the platinum plates exercises a certain influence on the quantity of gas developed; an influence which in weak currents manifests itself by the circumstance that large plates yield a less quantity of gas than small ones. Several causes of disturbance can come into play here: 1. Impurity of the decomposing fluid. Sulphuric acid often contains traces of oxide of lead and nitric acid, by which a portion of the hydrogen is oxydized. If combinations of chlorine be present, the development of oxygen is diminished. 2. Solubility of the gases in the fluid; this is particularly manifest with dilute sulphuric acid. It is therefore a rule to fill the voltameter with acid of a specific gravity of 1.3. 3. Finally, a gradual recombination of the developed gases. Besides these long known results Martens and Maas(2) present us with a new one, namely, that the electrolytic law is only approximately correct, inasmuch as a portion of the current is always conducted through the fluid, without decomposing the latter.—The experiments on which this assumption is based, were made with a mixture of 1 part of sulphuric acid to 20 or 30 of water, hence with a very dilute acid, for the purity of which, in particular, we do not possess the slightest guarantee. If the two physicists above-named had collected the gases separately, they would probably have made the farther discovery that the notion hitherto held regarding the composition of water out of 2 vols. hydrogen and 1 vol. oxygen is only an approximation to the truth.

Electroscopic Measurements.—Kohlrausch(3) has communicated new measurements of the electro-motive force of the circuit of Daniell. They, like his other experiments(4), are conducted electroscopically and with a degree of caution which excites confidence. They corroborate the result of the former experiments, that the electric force of the circuit is compounded of the algebraic sum of the single excitations which take place between its solid and fluid portions, and is of the same value when the circuit is closed as when the circuit is open. The limit within which this result is valid may be inferred from the fact that the strongest current which passed through the circuit was able to deflect the needle of an ordinary

(1) Pogg. Ann. XLII, 307; see also Pogg. Ann. XLVII, 226.

(2) *Ann.* 1850, 30.

(3) Pogg. Ann. LXXIX, 177.

(4) Annual Report for 1849, III, 135.

tangential galvanometer a few degrees only. For the electric differences of the single components of the circuit of Daniell, Kohlrausch finds the following comparable numerical expressions, which however he regards as only approximately correct:

Electro-
scopic
measure-
ments.

If the electric difference of zinc and copper be called	.	.	4.17
then the difference of zinc and sulphate of zinc is	.	.	5.40
" " " " zinc and dilute sulphuric acid	.	.	4.80
" " " " copper and sulphate of zinc	.	.	1.50
" " " " copper and sulphate of copper	.	.	0.90

An excitation between sulphate of copper and sulphate of zinc does not take place, or if so, it is so small that its effect can at most be only about $\frac{1}{10}$ of the action between zinc and copper.

Polarization.—Bismuth, combined with copper in dilute acids to an electric circuit, gives first a current directed through the fluid from the former metal to the latter; the strength of the current diminishes rapidly, and after a short time its direction becomes quite reversed. Henrici(1) explains this deportment by referring it to a slight power of decomposition on the part of the copper, by which the latter metal, even without being a member of an electric circuit, becomes coated with a layer of hydrogen.

The heating or shaking of the strips of platinum forming the ends of a galvanic circuit when dipped into a decomposition-cell, causes, as is known, particularly when the negative pole is the one so operated on, an accession to the strength of the current. In the closer investigation of this deportment Beetz(2) has observed that though it in general increases when the immersed plates are more strongly polarized; still, with weak currents it is always more strikingly developed than with strong ones. If strong currents be made use of, it is almost indifferent which of the two plates is heated or shaken. In the case of weak currents alone the negative pole exhibits a peculiarity.

The polarization of platinum plates by oxygen and hydrogen, decreases, as is known, when the temperature is increased. According to Beetz(3), the curve which expresses the ratio of diminution differs but little from a straight line. Some results of Robinson(4) coincide with this. More sensibly divergent, however, are the values contemporaneously communicated by E. Becker(5).

In the following table, some of the numbers furnished by these three observers are given for the sake of comparison.

(1) Pogg. Ann. LXXIX, 568.

(2) Pogg. Ann. LXXIX, 98; Arch. Ph. Nat. XIII, 282.

(3) Pogg. Ann. LXXIX, 109.

(4) Transactions of the Irish Academy, XXI, 297.

(5) Ann. Ch. Pharm. LXXIII, 6.

Resistance
of sulphuric
acid to con-
duction.

Polarization according to :

Temperature.	Beetz.	Robinson.	Becker.
20°	47.4	47.4	47.4
30°	46.9	—	45.6
60°	44.8	44.9	44.2
80°	43.6	—	42.3
97°	41.1	41.9	—
100°	40.7	—	36.3

Becker determined the polarization without opening the circuit, while Beetz conducted his measurements with the current interrupted. It is, therefore, very probable that the numbers of the latter, especially at the lower temperatures, are somewhat too small.

Resistance of Sulphuric Acid to Conduction.—E. Becker(1) has extended his investigations on the resistance of sulphuric acid at different temperatures, described in the last Report(2), to different degrees of concentration. The result of the inquiry is, that for the same degree of dilution the resistance of sulphuric acid to conduction decreases more rapidly with the increase of temperature the greater the degree of concentration possessed by the acid; and that for the same temperature the decrease of resistance due to the dilution of the acid is more considerable when the temperature is low; the rule, however, holding good only to the point at which a minimum resistance is obtained, so that by farther dilution the resistance again increases. This minimum corresponds pretty nearly to gravity, 1.25, possessed by the acid at 0°. The minimum value found by Horsford(3) falls about the same point. The law of the change of resistance of sulphuric acid, between the intervals of temperature 0° and 28°, when the fluid contained from 14.1 to 77.1 per cent SO₃, H₂O, has been expressed by Becker in the following formula, where t denotes the temperature, and p the quantity of hydrate of sulphuric acid in 100 acid :

$$r = 3.82965 - 0.106737 t + 0.004841 t^2 - 0.0000438 t^3 \\ + (0.14085 - 0.0060 t + 0.0000011 t^2) p \\ - (0.006668 - 0.000082236 t) p^2 \\ + 0.000092665 p^3$$

Beyond the limits above-mentioned this formula is inapplicable.

Resistance of the Earth to Conduction.—Matteucci(4) finds that in masses of earth of all kinds the resistance to conduction decreases the more they are penetrated with moisture and the deeper the plates are sunk, the size and chemical nature of the surface also

(1) *Ann. Ch. Pharm.* LXXV, 94.

(2) *Annual Report* for 1849, III, 141.

(3) *Pogg. Ann.* LXX, 238.

(4) *Compt. Rend.* XXX, 774; *Arch. Ph. Nat.* XIV, 212; *Instit.* 1850, 331, 380.

exerting a certain influence. The resistance does not increase in the same ratio as the length of the layer of earth increases. On the contrary, beyond a certain length, which in no case is considerable, the resistance is constant(1).—Some remarks of J. Napier(2) on the resistance of the earth to conduction present nothing new.

Resistance
of the
earth to
conduc-
tion.

Telegraphic Conduction.—Siemens(3) reports upon the nature and peculiarities of subterranean conduction.

Luminous Arc.—Despretz(4) has put together a battery, consisting of 600 elements of Bunsen, with which, under ordinary atmospheric pressure, he obtained by means of coal points an arch of light almost 2 decimetres in length, when the positive pole stood above the negative. Numerous other experiments which he made with this apparatus have led to nothing essentially new.

Matteucci(5) gives notice of an investigation, in which he states that he has strictly proved that the difference of temperature of two wire points, with which the arc of light is formed, and which are taken from the same metal, increases with the non-conductivity of the metal for electricity. From the decomposition of water, which took place during the existence of the arc, the points being always 3 millimetres asunder, Matteucci deduces the law that the arc of electric light increases in conducting power according as the conductivity of the substances between which the arc is formed is diminished. When, for instance, the light was formed between points of copper, coke, zinc and tin, the quantities of gases were in the ratio of the numbers 23:29:35:45, while in the well-closed circuit the quantity decomposed corresponded to the number 46.

The known experiments of Neef, on the exhibition of the electric light at the negative pole, have been subjected to examination by Moigno(6), the apparatus made use of being a moderator and fixer of the electric light, constructed by J. Duboscq(7). Moigno confirms: 1. That the light always appears at the negative pole, and that this primitive light is independent of the combustion; 2. that the source of heat is in reality the positive pole, and that this heat is originally dark; 3. that the phenomena of light and heat are not coincident until their intensities are increased to a certain

(1) Comp. Annual Report for 1849, III, 143; the Papers quoted in that place are also published in Pogg. Ann. LXXX, 374, 381.

(2) Phil. Mag. [3] XXXVII, 390.

(3) Pogg. Ann. LXXIX, 481; Ann. Ch. Phys. [3] XXIX, 385; Compt. Rend. XXX, 434.

(4) Compt. Rend. XXX, 367; XXXI, 418; Instit. 1850, 106, 297; for the former experiments of Despretz we refer to the Papers quoted in Annual Report for 1849, III, 24.

(5) Compt. Rend. XXX, 201; Instit. 1850, 83; Arch. Ph. Nat. XIII, 231.

(6) Compt. Rend. XXX, 359; Instit. 1850, 99; Pogg. Ann. LXXXI, 318.

(7) Compt. Rend. XXXI, 807.

Thermo-
electricity.

degree. From the combination of both arise the phenomena of flame and combustion(1).

Thermo-electricity.—Among the planes of cleavage of crystallized bismuth and antimony, one is distinguished from all others by its brilliancy. This plane is perpendicular to the principal axis of the crystal. A. F. Svanberg(2) cuts out of a crystallized mass pieces parallel to the cleavage of greatest brilliancy (*A*), and others perpendicular to this direction, that is, parallel to the principal axis of the crystal (*B*). He then finds that in the thermo-electric series the bar *A* is more positive, and the bar *B* more negative than all others that can be taken from the same mass. That is to say, every bar cut from the mass in other directions is negative compared with *A*, but positive compared with *B*. It had been already observed, that when two pieces of bismuth or of antimony of unequal temperatures were brought into contact, a current was the consequence. Now Svanberg has found the distinct law of action to be, that when two bars of the description *A*, and of unequal temperatures, are united, a current is excited which passes from the cold to the warm metal; if the bars are of the description *B*, the matter is reversed.

Henrici(3) describes numerous observations on the exhibition of thermo-electric phenomena between metals of the same kind when they are unequally heated at the place of contact.

Velocity of Electricity.—The velocity of electricity was, as is known, first determined by Wheatstone, in the year 1834, by means of a very ingenious apparatus devised by himself(4). The velocity in copper-wire is, according to this, 288,000 English miles, 62,500 German miles, or 460,000 kilometers per second. Of late years the wires of electric telegraphs have been made use of in different places to effect such measurements, the results of which make the velocity considerably less than that deduced from the experiments of Wheatstone. Thus Walker(5) in America, found the velocity in iron-wires to be 30,000 kilometers; O. Mitchell(6), in Cincinnati, who does not state the substance of his wire, finds for the same only 28,524 English miles. The latest of these measurements, by Fizeau and Gonnelle(7) is less divergent. According to them, the velocity in copper-wires amounts to 180,000 kilometers, and in iron-wires 100,000 kilometers. It is not proportional to the con-

(1) See Annual Report for 1847 and 1848, I, 237; for 1849, III, 144.

(2) Compt. Rend. XXXI, 250; Instit. 1850, 266; Arch. Ph. Nat. XV, 128.

(3) Pogg. Ann. LXXX, 167.

(4) Phil. Trans. for 1835, II, 583; Pogg. Ann. XXXIV, 464.

(5) Steinheil in Astron. Nachr. No. 679; Compt. Rend. XXX, 438.

(6) Phil. Mag. [3] XXXVI, 284; Instit. 1850, 294; Pogg. LXXX, 161.

(7) Compt. Rend. XXX, 437; Instit. 1850, 121; Arch. Ph. Nat. XIV, 38; Pogg. Ann. LXXX, 158.

ductive capacity, and is independent of the thickness of the wire. Induction.
 The number and nature of the galvanic elements have no influence upon the result.

Induction.—Wartmann(1) has raised the question, whether the development of magnetism or diamagnetism in the conductor of a current exerts any influence on the resistance, and has furnished the reply that no such influence exists.

Cellérier(2) has endeavoured to carry out a mathematical development of the general laws of electro-dynamic actions.

(1) Arch. Ph. Nat. XIII, 35; Phil. Mag. [3] XXXV, 423

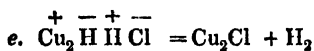
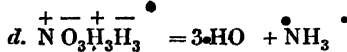
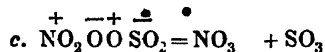
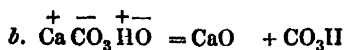
(2) Compt. Rend. XXX, 693; Instit. 1850, 177.

INORGANIC CHEMISTRY

General
matters.
Condition
of the ele-
ments at
the mo-
ment of
chemical
change.

General Matters. Condition of the Elements at the Moment of

Chemical Change.—Brodie(1) has published some observations on the condition of certain elements at the moment of chemical change; the following propositions are laid down by him as a starting-point: "1. That when two particles chemically combine, a certain chemical relation exists between them, which is expressed by the terms *positive* and *negative*. The chemical difference of the particles determines the difference between their conditions in this respect. 2. That when chemical combination takes place between the particles of which any two or more substances consist, a chemical difference exists between the particles of each substance, so that the particles of the same substance are to one another in a positive and negative relation. 3. That the chemical relation between any two particles of these substances is determined by the chemical relation of all the other particles with which they are for the time being associated; substances, the particles of which are to one another in this particular chemical relation, he terms *chemically polar*."—We give here a few examples of the mode in which Brodie views chemical polarization in certain cases: *a*. In the formation of oxide of silver from chloride of silver and potassa. The particles of silver and oxygen acquire only by their association with the chlorine and potassium the polarization necessary for the chemical combination, whilst silver and oxygen do not combine in their isolated state. *b*. In the decomposition of carbonate of lime by heat with the co-operation of steam. (According to Faraday, carbonate of lime by itself—dry—is not decomposed even at the highest temperatures.) *c*. In the transformation of sulphurous acid into sulphuric acid by the action of nitric oxide and oxygen. *d*. In the formation of ammonia when hydrogen and any oxide of nitrogen are passed over heated spongy platinum. *e*. In the disengagement of hydrogen from hydride of copper, Cu_2H (discovered by Wurtz), and hydrochloric acid:



General matters.

Condition of the elements at the moment of chemical change.

The latter example shows the view Brodie entertains of the *formation of elements*, in some instances, in their isolated state. He considers that this formation depends upon the union of two atoms of the same element in an opposite state of polarization, the element thus liberated being a *product*, whereas generally it is simply considered as an elimination of the elementary atom, the element set free being an *educt*. On adding solution of bichromate of potassa to a concentrated solution of peroxide of barium in hydrochloric or nitric acids, a copious disengagement of oxygen takes place; in this instance, according to Brodie, the oxygen of the peroxide of hydrogen attracts that of the chromic acid by its affinity for it, in consequence of its being in an opposite state of polarization, and both unite to form free oxygen. The decompositions of peroxide of hydrogen (in acid solutions or peroxide of barium) are considered by Brodie as being effected partly by contact, as for instance, with platinum, and charcoal; partly by chemical affinity, as with iodine; partly by a combination of both these modes, as in the case of chloride of silver, oxide of silver, &c. For the particular experiments on this point by Mr. Brodie, see peroxide of barium.

Constitution of the Salts or Oxides, R₂O₃.—Laurent(1) has communicated his views on the salts of the oxides R₂O₃. In order to render the formulæ of these salts analagous to those of the oxides RO, two modes of viewing them have been attempted. Peligot deems it probable that the oxides of uranium and of antimony(2) are oxides of an oxygenated radical, *uranyl* and *antimonyl*, represented by the formulæ (U₂O₂)O and (Sb₂O₂)O. The oxide of antimony he regards as constituted according to the formula R₂O₃, taking, in accordance with many other chemists, the atomic weight of antimony as one-half only of that adopted in this Report and in the subsequent formulæ. Laurent(3) assumed a metal of different atomic weight in the sesquioxide of iron, Fe₂O₃, to that in the protoxide, FeO, and proposed to write the formula of the sesquioxide of iron = feO, and to express in a similar manner the composition of the oxides of chromium, alumi-

(1) Compt. Rend. XXX, 673; Arch. Ph. Nat. XIV, 226.

(2) Annual Report for 1847 and 1848, I, 327.

(3) Annual Report for 1849, III, 148.

Constitution of the salts of the oxides R_2O_3 .

nium and others, at present generally designated by the formula R_2O_3 , by the more correct formula rO .—Laurent is now of opinion that none of the above views suffice alone for all the salts of the oxides of antimony, bismuth, chromium, aluminium, of sesquioxide of iron, &c., and that for these oxides two different isomeric states have to be assumed in both of which they form salts; one of them containing the oxides $(XO_2)O$, such as oxide of antimonyl $(SbO_2)O$, of bismuthyl $(BiO_2)O$, of ferryl $(FeO_2)O$, of chromyl $(Cr_2O_2)O$, &c.; the other containing the oxides rO , as oxide of antimony sbO , of bismuth biO , of chromium crO , sesquioxide of iron feO , &c. He attempts to deduce from this, for instance, the cause of the two different series of salts (green and violet) of the sesquioxide of chromium, and of the changes which those compounds of the oxides R_2O_3 , that are analogous to tartar emetic, undergo at high temperatures.

Determination of Atomic Weights by Electrolysis.—Osann(1) has communicated some experiments, which had for their object to determine the relative proportions of the atomic weights of zinc, copper and water, by electrolysis, on the basis of Faraday's electrolytical law; he did not, however, obtain numerical results of sufficient accuracy.

Oxygen.—According to Schönbein(2), oxygen acts much more powerfully oxydizing in sunshine, than in the dark; paper stained with the sulphides of lead, arsenic or antimony, was rapidly discolored when exposed to the light, but not in the dark. Moist hydrated protoxide of lead appeared to be converted into a kind of minium (red lead) by the action of oxygen under the influence of light.

Ozone.—The papers on ozone, published during 1850, contain no new information. Becquerel, Sen.(3) has given a recapitulation of Schönbein's observations; the essential portion of a paper by Osann(4) has been already mentioned in last year's Report, p. 150, and that of a paper by Schönbein(5), p. 149.

Hydrogen.—In order to exhibit, in lectures, the combustion of hydrogen in oxygen and salt-radicals, Bussy(6) recommends the gradual immersion of the flame of the hydrogen, issuing from a glass tube U-shaped at one end, into a tall glass cylinder filled with oxygen, chlorine, or the vapour of bromine or iodine. In chlorine gas, the flame becomes larger and blueish-white; in the vapour of bromine it still continues to burn with formation of hydrobromic acid if, at the same time, a little air have access to it; but in the vapour of iodine it is extinguished.

(1) Neue Beiträge zur Chemie und Physik, 6. Lief., 171.

(2) Arch. Ph. Nat. VV, 89; J. Pr. Chem. LI, 267; Ann. Ch. Pharm. LXXVI, 225 (in abstr.)

(3) Compt. Rend. XXX, 13.

(4) J. Pr. Chem. L, 209.

(5) J. Pr. Chem. LI, 321.

(6) J. Pharm. [3] XVII, 20; J. Pr. Chem. L, 62.

Carbon.—Despretz(1) has confirmed, by a new series of experiments, his former statement(2), that charcoal, under the influence of heat generated by powerful galvanic batteries, is first converted into graphite, then fuses, and at a still higher temperature volatilizes.—Jacquelain(3) has found, and Despretz(4) confirmed, that diamond passes into the state of coke or graphite, when acted upon by the intense heat produced by a powerful galvanic battery: Gassiot(5) observed that diamond, under the influence of heat generated by a powerful Grove's battery between two charcoal points, at first gradually increased its volume, and then suddenly swelled to 8 or 10 times its original size, when it had assumed a glassy, white, opaque appearance, and had become a non-conductor of electricity. In other experiments the diamond was shivered to fragments, having the appearance of charcoal.

Respecting Schönbein's(6) observations, that charcoal possesses the power of reducing higher oxides in the moist way, Esprit(7) has pointed out that Schönbein does not appear to have taken into account the influence of the metallic sulphides and other impurities contained in charcoal. Esprit firmly contradicts Schönbein's statement, that protochloride of mercury (corrosive sublimate) in an aqueous solution is converted into the subchloride (calomel) by shaking it with powdered charcoal; the protochloride is certainly hereby removed from the solution, but unites unchanged with the charcoal, and can be extracted from it by means of a mixture of alcohol and ether. Esprit again states his opinion(8) that the action of the charcoal on solutions of metallic salts, does not consist in the enclosure of them in the pores of the charcoal, but rather in a peculiar affinity, similar to that which causes solution, in contradistinction to true chemical combination.

Carbonic Oxide.—The following observations on carbonic oxide have been communicated by F. Leblanc(9). The hydrochloric solution of subchloride of copper absorbs carbonic oxide rapidly and in considerable quantities, with feeble elevation of temperature; an ammoniacal solution, containing the same amount of copper, absorbs as much, and the solution, on being exposed to the air, is rendered blue by absorption of oxygen. The hydrochloric solution of the subchloride of copper, saturated with carbonic oxide, can be diluted with a large quantity of water, without a separation of subchloride or

(1) Compt. Rend. XXX, 367; Instit. 1850, 10.

(2) Annual Report for 1849, III, 24.

(3) Annual Report for 1847 and 1848, I, 253.

(4) Annual Report for 1849, III, 25.

(5) Chem. Gaz. 1850, 338; Instit. 1850, 327.

(6) Annual Report for 1849, III, 151.

(7) J. Chim. Méd. [3] VI, 502; Ann. Ch. Pharm. LXXXVI, 276 (in al. str.)

(8) Annual Report for 1849, III, 151.

(9) Compt. Rend. XXX, 483; Instit. 1850, 129; Pogg. Ann. LXXXII, 142; J. Fr. Chem. L, 239.

Carbonic
oxide.

of gas being effected; it is not rendered turbid by the addition of alcohol; ether, however, appears to effect decomposition. Leblanc is of opinion that a combination in definite proportions is formed, containing equal equivalents of copper and carbonic oxide. He did not succeed in isolating this compound; on boiling and *in vacuo* carbonic oxide escapes. Other salts of the suboxide of copper absorb likewise carbonic oxide when dissolved in ammonia—for instance, the sulphite. The salts of the protoxides of iron and tin exert no influence on carbonic oxide.

Carbonates.—Sénarmont's experiments on the production of carbonates with such properties, as are exhibited by the native carbonates, have already been mentioned in our last year's Report, p. 152, according to an abstract previously published. They have now been communicated in full(1), and we complete therefore our former Report by the following statements.—Besides the method already described, the following can be used for the production of these carbonates: A strong vessel of stoneware is nearly filled with a solution of the bicarbonate of an alkali supersaturated with carbonic acid, and then a soluble salt of the metal, the carbonate of which is to be procured, is introduced, enclosed in a globe of glass; the vessel is now closed by means of cork, gypsum, &c., in such a manner that the carbonic acid can only escape through it under a strong and continuous pressure; the globe is now broken at an elevated temperature by means of an iron rod passing through the aperture; the carbonate then formed dissolves in the excess of carbonic acid, and is precipitated as the latter gradually escapes.—In addition to the carbonates mentioned in our former Report, Sénarmont has prepared the following: *Carbonate of cobalt*, obtained by the action of chloride of cobalt on carbonate of lime at 150° during eighteen hours, or by decomposing chloride of cobalt at 140° by means of a solution of bicarbonate of soda supersaturated with carbonic acid; it forms a crystalline, light rose-coloured, sandy powder, which, in the cold, is not attacked even by concentrated hydrochloric or nitric acids. In the same manner, and with the same properties, excepting that it was of a greenish-white colour, *carbonate of nickel* was obtained. *Carbonate of copper* could not be produced.—The composition of the carbonates described, here and in last year's Report, corresponding to the general formula RO, CO_2 , was established by analysis.—The form of rhombohedrons could distinctly be recognised under the microscope in the carbonates of magnesia, cobalt, nickel and protoxide of iron.

Boron. Borates.—Laurent(2) has published a paper on the *borates*. The formulæ he ascribes to the various salts are based partly on

(1) Ann. Ch. Phys. [3] XXX, 129; Pr. Chem. LI, 385 (in abstr.)

(2) Laurent and Gerhardt, C. R. 1850, 33; Ann. Ch. Pharm. LXXVI, 257 (in abstr.)

observations of his own, partly on new interpretations of the results obtained by other chemists; we consider here chiefly the former, and give Laurent's formulæ; they are however translated into the atomic weights adopted in this Report. Laurent expresses the composition of the neutral borates by the general formula $B_2O_3M_2$ ($=2MO, B_2O_6$), where M_2 may be represented either by a metal, by ammonium, or by hydrogen. Boracic acid itself he considers as bibasic(1).—The *potassa-salts* examined are: $B_2O_3KII + 4HO$ (six-sided prisms); $B_2O_3KH + 5HO$ (in one instance instead of the former salt, right rhombic prisms of $98^\circ 35'$ were obtained, with the more acute edges truncated; this salt, when kept in a closed vessel for several days, is transformed into a solid mass with supernatant solution); $B_2O_3K\frac{2}{3}H\frac{1}{3} + 4HO$ (rectangular prisms $\infty \bar{P} \infty . \infty \bar{P} \infty$ with $x \bar{P} \infty, y \bar{P} \infty$ and ∞P ; $\infty P : \infty \bar{P} \infty = 164^\circ$; $\infty \bar{P} \infty : x \bar{P} \infty = 125^\circ$; $y \bar{P} \infty : \infty \bar{P} \infty = 132^\circ 15'$); $B_2O_3K\frac{1}{2}H\frac{1}{2} + 3HO$ (in crystals like those of the corresponding ammonia-salt; this salt does not lose its hydrogen completely when ignited by itself only, but after some carbonate of lime has been added).—Of *ammonia-salts* Laurent assumes two, in addition to the one described by Arfvedson $B_2O_3(NH_4)\frac{3}{2}H\frac{1}{2} + HO$, formerly denoted by $\frac{1}{2}$ borate of ammonia, viz.: $B_2O_3(NH_4)H + 3HO$ (crystals formed in a solution of boracic acid in an excess of ammonia, which become immediately opaque when removed from the mother-liquor), and $B_2O_3(NH_4)\frac{1}{2}H\frac{1}{2} + 3HO$ (from ammonia and an excess of boracic acid; monoclinometrical pyramids $+P. -P$ with $\infty P \infty$ and $[\infty P \infty]$; and twin crystals; $+P : +P = 114^\circ 15'$, $-P : -P = 115^\circ 15'$, $+P : -P = 117^\circ$; when fused by itself it loses incompletely its water and ammonia).—Laurent's results respecting Bolley's *soda-salt* have already been communicated in our last year's Report, p. 153.—The following *baryta-salts* have been investigated by Laurent: $B_2O_3Ba_2 + 20HO$ (obtained in form of a white, flocculent precipitate on adding a hot solution of Bolley's salt, to a hot solution of nitrate of baryta); $B_2O_3Ba\frac{2}{3}H\frac{1}{3} + 10HO$ (obtained by the decomposition of the same salt under circumstances not specified); $B_2O_3BaH + 4HO$ (obtained as a flocculent precipitate by dropping nitrate of baryta into an excess of solution of borax and ammonia); $B_2O_3Ba\frac{3}{4}H\frac{1}{4} + 9HO$ (obtained in form of a crystalline powder on dropping a hot solution of nitrate of baryta

(1) Boracic acid is bibasic when the atomic weights of this report are adopted; according to Laurent's mode of designation it is quadribasic, because he assumes the atomic weights of hydrogen and of the metals as only half as large in relation to that of oxygen.

Borates. into an excess of a solution of Bolley's salt, which should be stirred all the time).—*Strontia-salts*: $B_2O_3SrII + 3 HO$ (dried at 100° ; obtained by adding a boiling solution of borax to a boiling solution of chloride of strontium, the 3 HO escape at 280°); $B_2O_3Sr\frac{1}{2}H\frac{1}{2} + 2HO$ (obtained in form of a white powder by boiling a solution of the preceding salt with boracic acid and evaporating).—*Lime- and magnesia-salts*: $B_2O_3Ca\frac{1}{2}H\frac{1}{2} + 3 HO$ (is deposited as a powder on boiling milk of lime with an excess of boracic acid); $B_2O_3Mg_2 + 8 HO$ (prepared by adding a boiling solution of borax to a boiling solution of nitrate of magnesia); $B_2O_3Mg\frac{1}{2}H\frac{1}{2} + 4 HO$ (on boiling an excess of a solution of boracic acid with carbonate of magnesia and filtering it, a liquor was obtained which deposited first boracic acid, and then, by spontaneous evaporation, this salt).—Borax added to a hot solution of sulphate of copper, yielded a green precipitate, the composition of which, when dried at 100° , is expressed by the formula $B_2O_3Cu_2 + 2 CuO + 5 HO$.

Borate of Soda.—E. Schweizer(1) has made experiments on borax, especially on its deportment with feeble acids.—A solution of borax, evaporated at 100° , leaves an amorphous, transparent, brittle mass, which when dried at 100° until its weight remains constant, possesses the composition $NaO, 2 BO_3 + 4 HO$. When evaporated below 90° , borax assumes a crystalline form.—A solution of borax, saturated whilst cold, absorbs as much carbonic acid as would suffice to convert the soda contained in the borax into carbonate of soda. A solution thus saturated with carbonic acid has a feeble acid reaction, and disengages much carbonic acid on addition of a stronger acid, ^{alt} at a certain degree of concentration on being evaporated. From a solution of borax completely saturated with carbonic acid no borax is separated, even after some time, when it is mixed with its bulk of alcohol; whilst the addition of alcohol to a pure (even very dilute) solution of borax effects an immediate and nearly complete precipitation of borax in a crystalline form. Borax is consequently decomposed by carbonic acid, perhaps quadriborate and bicarbonate of soda being formed, or more likely carbonate of soda and free boracic acid.—Sulphuretted hydrogen also decomposes borax with formation of sulphide of sodium and free boracic acid. An aqueous solution of borax absorbs sulphuretted hydrogen in considerable quantity, which again escapes on adding hydrochloric acid, and on evaporating. A solution of borax treated with sulphuretted hydrogen contains hyposulphite of soda, when exposed to the air for some time. On mixing a solution of borax, completely saturated

(1) Mitth. d. Naturforsch. Gesellsch. zu Zürich, 1850, 1; Ann. Ch. Pharm. LXXVI, 267; Chem. Gaz. 1850, 281.

with sulphuretted hydrogen, with twice its bulk of alcohol, no separation of borax takes place; if ether be added to the alcoholic liquor until two layers are formed, the lower yellowish one contains sulphide of sodium, and the upper boracic acid—Schweizer deems it probable that borax is decomposed even by being dissolved in water, and not partially only (as Barreswil previously suggested), but entirely, boracic acid and (mono-) borate of soda being formed.—Silicic acid, in its soluble modification, does not exert a decomposing influence on borax. A very dilute solution of borax, left for some time in contact with pure gelatinous silicic acid, contained only a very small quantity of the latter, and on adding alcohol, the borax separated unchanged.—A solution of borax, saturated while cold, dissolves a considerable quantity of arsenious acid without separating boracic acid, a compound very soluble in water being formed. In order to prepare this compound, a cold saturated solution of borax was digested with finely-powdered arsenious acid for some time on a water-bath; the liquor was evaporated at 100° , and poured off the crystals of borax which deposited, on allowing it to stand; it was then evaporated to the consistence of syrup; on a little water being added, crystals of borax again separated, from which the liquor was poured off; then again strongly evaporated, left standing in the cold for some time, freed from some brownish flakes which had deposited, and now completely inspissated. The residue remained for a long time soft and viscous, and became solid, brittle, gum-like, and of a slightly yellowish colour, when heated for several days. It was dissolved in as little water as possible, freed from some traces of arsenious acid which had separated, and evaporated under the air-pump. The mass, after remaining for several weeks *in vacuo*, contained the elements of 3 equivs. of tetraborate of soda, 5 equivs. of arsenious acid, and 10 equivs. of water (found by analysis 55.55 per cent of arsenious acid, 10.50 per cent of soda, 20.55 of boracic acid, and 13.40 of water). It was almost insoluble in alcohol, but dissolved readily in water; forming a liquid of an alkaline reaction, rendered gradually somewhat turbid in the air, and from which it did not separate in crystals, even when evaporated as slowly as possible. A solution of the consistence of a syrup solidified in snow to a white, radiated, crystalline mass, again becoming liquid at the ordinary temperature. Schweizer thinks that the proximate constituents of this compound are arsenite of soda, borate of soda, and a compound of arsenious acid with boracic acid.—Organic acids are freely dissolved by solution of borax. The liquor obtained by digesting a cold saturated solution of borax with benzoic acid, and strongly evaporating at 100° , yielded crystalline scales of benzoic acid; the mother-liquor, when gently evaporated, gave crystals of benzoic acid; and the thick liquid separated from them left, on farther evaporation, a white, silky mass, readily soluble in water and alcohol, and con-

Borate of
soda.

taining soda, boracic acid, benzoic acid, and water. Tannic and gallic acids behave with borax like arsenious acid, a compound of the organic acid and the constituents of borax being formed, which is easily soluble in water. The compound of gallic acid, when dried, forms a gummy mass; that of tannic acid a yellowish powder, possessing no longer an astringent taste, and the aqueous solution of which solidifies to a gelatinous mass on addition of an acid. Margarine, stearic and oleic acids are dissolved in considerable quantities by solution of borax; a clear solution, saturated whilst warm with stearic acid, is on cooling completely converted into a jelly. Colophony is also readily soluble in a solution of borax.

Phosphorus.—R. F. Marchand(1) has made investigations on the luminosity of phosphorus. He concurs with the view of Berzelius(2), according to which luminosity of phosphorus can ensue without simultaneous oxidation, as the effect of evaporation and molecular change thereby produced. Marchand found that phosphorus becomes luminous in all gases, and also in all vapours, except in those cases when the substances forming, or being contained in, the atmosphere round the phosphorus are combining chemically with it. In some gases, phosphorus is rendered luminous at very low temperatures; whilst in some vapours it has to be heated to the boiling-point. The luminosity by evaporation differs from that which appears on oxidation; it continues as long as any of the phosphorus can evaporate, but ceases whenever the phosphorus is covered with a skin preventing evaporation. Marchand examined the deportment of phosphorus contained in a current of gas; in a closed space, filled with a limited quantity of gas, the luminosity soon ceases, because the space becomes soon saturated with the vapour of phosphorus, and farther evaporation is then impossible. In a current of pure hydrogen, phosphorus was distinctly luminous; a sudden increase of the current produced an instantaneous increase, and then a cessation of the lumination; phosphorus was still luminous at -15° . In a current of carbonic acid, the phosphorus exhibited the same deportment. The vapour of ether, petroleum, oil of turpentin, or sulphuretted hydrogen, added to the hydrogen, prevent the phosphorus from being luminous in it; by raising the temperature, however, it may again be rendered luminous even with these admixtures, and by heating to boiling even in the vapour of pure ether. In dry atmospheric air, hydrogen or carbonic acid, phosphorus ceases to be luminous at 15° , when the pressure is increased to 2 atmospheres; on suddenly removing the increased pressure, the phosphorus again becomes luminous, and, for a short time, luminous vapours are

(1) J. Pr. Chem. L, 1; Berichte der Gesellsch. d. Wissenschaften zu Leipzig, 1849, III, 126 (in abstr.); Ann. Ch. Pharm. LXXVI, 222.

(2) Lehrb. d. Chem. 5 Aufl. I, 195.

formed.—In dry oxygen, phosphorus does not continue long to be luminous, because it becomes coated with a crust of oxydized phosphorus, which prevents evaporation; when the phosphorus is carefully melted (so that no ignition ensues), whereby this crust is frequently broken, the luminosity continues longer in a current of such oxygen, and then, even when using perfectly pure oxygen, ozone is formed (contrary to the statement of Schönbein). Marehand observed phosphorus was still luminous at -12° in oxygen, and at -3° in atmospheric air. The luminosity of phosphorus in air, at a low temperature, is not, according to him, the effect of oxydation, but of evaporation.

Schrötter(1) has communicated, as a complement to his former investigations on amorphous phosphorus(2), that it can also be prepared in compact masses (previously obtained in form of a red powder only), when phosphorus is kept for a considerable time (eight days) as uniformly as possible at a temperature very near to that at which it is again transformed into its original state. Amorphous phosphorus thus obtained forms a coherent, reddish-brown mass, of an iron-coloured, conchoidal fracture, with imperfect metallic lustre, brittle, and the hardness of which is between that of calcareous spar and fluspar; its spec. grav. was found to be 2.089 to 2.106; these numbers are, however, too low, owing to an admixture of some common phosphorus. This admixture also causes amorphous phosphorus, thus prepared, to undergo oxydation, and even combustion, at the ordinary temperature. (On the formation of amorphous phosphorus, see also p. 186).—Schrötter likewise states, that phosphorus decomposes water from 250° to 260° . If moist phosphorus be sealed in a glass tube, and this be heated to the above temperature for some time, spontaneously inflammable phosphoretted hydrogen is disengaged on the tube being opened.

In a preliminary notice, Schrötter(3) mentions that the atomic weight of phosphorus is probably only 31, and not 32, according to experiments in which amorphous phosphorus was subjected to direct combustion in oxygen at

Phosphoric Acid. Völcker(4) has made a communication concerning the amount of phosphoric acid contained in some waters. He found in an irrigation from water of Cirencester, 1.25; in one of Edinburgh, 4.027; and in those of some marine boilers, 0.03 to 0.04 per cent of phosphoric acid.

Sulphur.—The statement occurring in Gmelin's Handb. der Chem. (4th ed. I, 602), "that the brown colour of amorphous sulphur might

(1) Pogg. Ann. LXXXI 299; J. Pr. Chem. LI, 155; Compt. Rend. XXXI, 138.

(2) Annual Report for 1847 and 1848, I, 255.

(3) Wien. Acad. Ber. November, 1850, 441.

(4) Chem. Gaz. 1850, 346; Instit. 1850, 341.

Sulphur. be caused by an admixture of asphaltum," was thought by Horsford(1) to have reference to *melted* sulphur; he prepared, therefore, sulphur from heavy spar, and found that it also assumed a brown colour on being melted.

Sulphites.—Mène and Vinchon(2) deny the existence of the bisulphites of lime, baryta, magnesia, and alumina; they state that the action of sulphite of lime in the manufacture of sugar, observed by Melsens(3), takes place only in presence of free acids which disengage sulphurous acid from the sulphite of lime.—The reactions of sulphite of soda with various metallic salts have been investigated by H. Hirzel(4).

Sulphuric Acid.—Kemp(5) recommends, for the purpose of purifying sulphuric acid from nitric acid, to dilute 3 vols. of oil of vitriol with 1 vol. of water, to pass sulphurous acid gas through the hot mixture, and to drive off the excess of it by boiling; or better, to mix 3 vols. of oil of vitriol with 1 vol. of water, previously saturated with sulphurous acid, and to boil this mixture. By mixing the oil of vitriol with half its bulk of aqueous sulphurous acid, the lead contained in the former was also completely separated; and the liquid, poured off the precipitate, and boiled down to a spec. grav. of 1.845, was almost chemically pure sulphuric acid.—Jacquelin(6) has attempted to reconcile the contradictory statements on the freezing-points of $\text{SO}_3, 2\text{H}_2\text{O}$, and of $\text{SO}_3, 3\text{H}_2\text{O}$. He found that in open tubes, and with continual stirring, $\text{SO}_3, 2\text{H}_2\text{O}$ congeals at 0° , and $\text{SO}_3, 3\text{H}_2\text{O}$ at $+8^\circ$; that, however, in sealed tubes these hydrates may be exposed to -35° and -40° , without becoming solid; but solidification suddenly takes place on opening the tube. He examined the density of aqueous acid of different composition, prepared partly by rapidly mixing hydrated sulphuric acid and water (A), partly by allowing the hydrate to attract *in vacuo* gradually a certain weight of water (B). He found the densities at 15° :

	$\text{SO}_3, 2\text{H}_2\text{O}$	$\text{SO}_3, 3\text{H}_2\text{O}$	$\text{SO}_3, 4\text{H}_2\text{O}$	$\text{SO}_3, 5\text{H}_2\text{O}$	$\text{SO}_3, 6\text{H}_2\text{O}$
A	1.7846	1.6662	1.5681	1.49	1.4313
B	1.7858	1.6746	1.5721	—	1.4538

The aqueous acids containing more than $2\text{H}_2\text{O}$, or SO_3 remain fluid in sealed tubes down to -40° , and in open tubes to -20° .—By passing the vapour of anhydrous sulphuric acid into the hydrate, $\text{SO}_3, \text{H}_2\text{O}$ until the latter was saturated, and then freeing the crystals

(1) Proceedings of the 2. American Association for the Advancement of Science, held at Cambridge, 234.

(2) Instit. 1850, 178.

(3) Annual Report for 1842, 11, 492.

(4) Zeitschrift f. Pharmacie, 1850, 9, 39.

(5) Proceedings of the Royal Society of Edinburgh, II, 298.

(6) Ann. Ch. Phys. [3] XXX, 343; J. Pr. Chem. LI, 461; Ann. Ch. Pharm. LXXVI, 233 (in abstr.)

formed from the liquor by continued pressure between porous tiles of porcelain, taking care to exclude moisture, Jacquelin obtained a compound melting at $+26^{\circ}$, crystallizing in thin, transparent prisms and fuming in the air, the composition of which corresponded to the formula $4\text{SO}_3, 3\text{HO}$.

Thionic acids.

Thionic Acids.—In examining the products of the action of sulphuretted hydrogen and sulphurous acid in water, Sobrero and Selmi(1) found in every instance, besides pentathionic acid(2), tetrathionic, hyposulphurous and sulphuric acids, but in no case trithionic acid; they are of opinion that the nature of the products of decomposition depends on the relative quantities of sulphuretted hydrogen and sulphurous acid, on the concentration of the liquor and on the temperature. On decomposing sulphuretted hydrogen and sulphurous acid in water, a considerable quantity of sulphur is separated, forming with a *small* quantity of water an emulsion, from which it is not deposited even after a considerable time, and with a *large* quantity of water an almost perfectly clear liquid. From the emulsion the sulphur is precipitated on adding an aqueous solution of a neutral soda-salt, and will again form an emulsion on being mixed with water; if, however, the sulphur be precipitated from the emulsion by means of a neutral potassa-salt (especially sulphate of potassa), it is obtained in form of a tough, elastic mass, remaining unchanged when kept even for several months; in this state it does not reproduce the emulsion on being mixed with water. Sobrero and Selmi point out that a considerable amount of sulphur may be contained in such a liquid without affecting its transparency to any extent, and without being actually dissolved.—Fordos and Gélis(3) observe, that the sulphur-acids found by Sobrero and Selmi, along with pentathionic acid, may be considered simply as products of decomposition of this very changeable acid. They add, at the same time, the following statements on the thionic acids (acids of sulphur with 5 equivs. of oxygen). These acids possess a greater stability when in contact with other acids; thus pentathionic acid formed from chloride of sulphur and water is much more slowly decomposed, if the water used be acidulated with sulphurous or hydrochloric acids instead of being pure. On the contrary, the aqueous solutions of the alkalies hasten the decomposition of the thionic acids with the exception of the dithionic; sulphuric acid is never formed in this decomposition. Pentathionic acid yields with potassa hyposulphite of potassa only: tetrathionic and trithionic acids give hyposulphite and sulphite

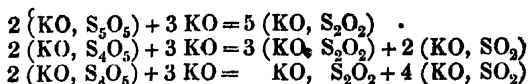
(1) Ann. Ch. Phys. [3] XXVIII, 210; J. Pr. Chem. XLIX, 417; Ann. Ch. Pharm. LXXVI, 237.

(2) Comp. Annual Report for 1847 and 1848, I, 284.

(3) Ann. Ch. Phys. [3] XXVIII, 451; J. Pr. Chem. L, 83; Ann. Ch. Pharm. LXXVI, 238 (in abstr.)

Bisul-
phide of
carbon.

of potassa; trithionic acid is only decomposed by protracted boiling with potassa, dithionic acid not at all.



Bisulphide of Carbon.—M. Scanlan and A. Anderson(1) think it probable that, besides sulphuretted, carbonetted, and phosphoretted hydrogen and carbonic acid, they have met with bisulphide of carbon in the gas escaping from the contents of a sewer.

Sulphides of Metals.—Sénarmont(2) has prepared several metallic sulphides in a similar manner to the carbonates, (see page 174;) he decomposed a soluble salt of the metal with a polysulphide of potassium at an elevated temperature. The sulphide of potassium was sealed up in an exhausted glass tube along with a glass bulb containing the soluble metallic salt and some air, so as to burst the bulb at an increased temperature and to effect the mixing of the contents.—*Bisulphide of Iron*, FeS_2 , was obtained by decomposing sulphate of protoxide of iron (at 165°) or protochloride of iron (at 180°) with a polysulphide of potassium; it is a black, amorphous powder, sometimes coating the tube with a metallic yellow lustre; exposed to the air it is scarcely oxydized whilst moist, and not at all so when dry, even after considerable time; it is inflammable, and not attacked by hydrochloric acid.—*Sulphide of Manganese*, MnS , is prepared with protosulphate of potassium; made at 185° , it is an amorphous, black powder, sometimes coating the tube with the colour of steel, little changeable in moist, and not at all in dry air. *Bisulphide of Manganese*, MnS_2 , prepared between 160° and 180° by means of a polysulphide of potassium, is a brick-coloured, amorphous powder, behaving in the air like the preceding.—*Sulphide of Cobalt*, Co_3S_4 , prepared at 160° from chloride of cobalt and a polysulphide of potassium, is an amorphous, blackish-grey powder, unchangeable in dry air.—By the action of proto- or polysulphide of potassium on chloride of nickel, at 160° , *Sulphide of Nickel*, NiS or Ni_3S_4 , respectively were obtained; both are amorphous, blackish-grey powders, sometimes coating the tube with a metallic, yellow lustre, and remain unchanged in dry air.—By using either mono- or polysulphide of potassium *Sulphide of Zinc* is formed (at 175°) of the composition ZnS , as a white, amorphous powder, unchangeable in the air.—Some of the sulphides thus prepared assume a crystalline appearance by the following method: Into a strong glass tube, almost filled with boiled water, some metallic sulphide and persulphide of hydrogen were put, the tube freed from air, and sealed up; sulphuretted hydrogen was formed and sulphur deposited; on heating (whereby explo-

(1) Chem. Soc. Qu. J. III, 13.

(2) Loc. cit. p. 174.

sions are very liable to occur) the metallic sulphide was dissolved, and on cooling it separated in a crystalline form. Iodine.

Iodine.—On the occurrence of iodine numerous researches have been made.—Müller at Rosswein(1) had previously observed that water-cresses (*Nasturtium officinale*) contain iodine. Chatin(2) has now found it in the ashes of all fresh-water plants, but none in those of land plants; the same species contained iodine when grown in fresh water, and none when grown on the land; plants grown in running water contained more iodine than those from stagnant water. The iodine is said to be contained in the juice of the plants in combination with an alkali-metal.—E. Marchand(3) has found iodine and bromine in the well-water of Fécamp, and the former also in fresh-water plants.—Bussy(4) also confirmed the occurrence of iodine in several fresh-water plants. He, moreover, found iodine in the products of distillation of coal(5); he states that the ammoniacal liquor from the manufacture of coal-gas contains iodide of ammonium, and that the coke remaining contains iodine. According to Méne(6) this ammoniacal liquor not only contains iodine, but also bromine.—Meyrac(7) found iodine and bromine in oscillaria in the thermal waters of Dax (département des Landes) and Personne(8) iodine in *Jungermannia pinguis*(9).—Lamy(10) and Fehling(11) found iodine in the potash manufactured from the molasses of the beet-root-sugar factory of Waghausel in Baden. The former found iodine also in the beet-roots of Waghausel, but none in the sugar (raw or refined) manufactured from them; he could not, however, discover a trace of iodine in the beet-root or in the potash of a sugar factory near Valenciennes.—In a later communication, Chatin(12) gives finally the following statements: iodine occurs in various fresh-water plants from all parts of the world, in coal and peat(13) and in fresh-water ani-

(1) Arch. Pharm. XXXV, 40; on the occurrence of iodine in plants of the sea-coast, compare Gregory, Ann. Ch. Pharm. XXXIV, 240.

(2) J. Pharm. [3] XVII, 418; J. Pr. Chem. L, 273; Compt. Rend. XXX, 352 (in abstr.); Instit. 1850, 97; Ann. Ch. Pharm. LXXV, 61; Bussy's Report, Compt. Rend. XXX, 467.

(3) J. Pharm. [3] XVII, 356.

(4) J. Pharm. [3] XVII, 431; Compt. Rend. XXX, 537; Instit. 1850, 145; J. Pr. Chem. L, 287.

(5) Fischer had previously found iodine and bromine in the coals of Silesia (Annual Report for 1847 and 1848, I, 289).

(6) Compt. Rend. XXX, 612; Instit. 1850, 153.

(7) Compt. Rend. XXX, 475.

(8) Compt. Rend. XXX, 478.

(9) Von der Marck has formerly found iodine in *Jungermannia albicans* (Annual Report for 1847 and 1848, I, 289).

(10) J. Pharm. [4] XVIII, 33; J. Chim. Méd. [3] VI, 322; J. Pr. Chem. LI, 187 (in abstr.).

(11) Ann. Ch. Pharm. LXXV, 67.

(12) Compt. Rend. XXXI, 280; J. Pharm. [3] XVIII, 241; J. Pr. Chem. LI, 277.

(13) Straub has already found iodine in the peat of the neighbourhood of Hofwyl (Gmelin's Handb. d. Chem. 4. Aufl. I, 677).

Iodine

mals (leeches, crabs, frogs, water-rats and others). Fresh water itself (whether river-, spring-, or well-water) contains iodine, and the more of it the greater the amount of iron it contains. The waters of volcanic-rocks are the richest in iodine, next those of the green chalk and ferriferous oolites, then those of the coal formation; but little iodine occurs in the waters of lime- and magnesia-rocks, and very little in those of red marls, the amount of iodine is not in proportion to that of chlorine. The waters from glaciers are poor in iodine. The amount of iodine in river-water is more uniform than that in spring-water, and both contain the less iodine the more the earthy salts abound. Iodine also exists in land-plants and in land-animals. The potashes of commerce(1) and most of the salts prepared from it (with the exception of saltpetre, cream of tartar, tartar emetic and Rochelle salt) contain iodine, and also the various sorts of sal-ammoniac and soda, and the common salt prepared from sea-water. Rock-salt and the common salt of the east of France are almost free from iodine. Fermented liquors (wine, cider, perry) contain iodine in varying amounts, the difference of the soil exerting hereby the same influence as in the case of the water. Milk is still richer in iodine than wine, and the milk of asses more so than that of cows. Eggs (but the shell) are rich in iodine. Iodine, finally, occurs in soil; freely in sulphur, the ores of iron and manganese, cinnabar; sparingly in gypsum, white chalk and coarse limestone.—E. Marchand(2), who claims from Chatin(3) the priority of the discovery of iodine in fresh water; maintains the following points. All water occurring in nature contains iodine, bromine, and lithium; in woody districts the iodine may be abstracted from the water by the plants; the ashes of most kinds of wood contain iodine; iodine and bromine are chiefly derived from the sea and are carried about by the vapour of water; rain- and snow-water usually contain iodine in appreciable quantities.

Kemp(4) recommends for the manufacture of iodine to divide the sea-weeds mechanically (particularly the species of *Laminaria*, which are especially rich in iodine during autumn), to ferment them with water, whereby the vessels containing the iodine-compounds are opened, to precipitate the liquor obtained, with a compound of starch and oxide of lead (prepared by treating starch with subacetate of lead), and finally to work the precipitate for iodine.—Herzog(5) has discussed the impurities of the iodine of commerce.

Iodic Acid.—Jacquelin(6) has compared the various methods for preparing iodic acid. He finds the preparation by means of iodine

(1) Iodine has previously been found by Preuss in commercial potashes (Ann. Ch. Pharm XXXIV, 239).

(2) Compt. Rend. XXXI, 495, J Pharm [3] XVIII, 358.

(3) Chatin's Reply, Compt Rend XXXI, 868.

(4) Chem. Gaz. 1850, 250.

(5) Arch. Pharm. [2] LXII, 155.

(6) Ann Ch Phys [3] XXX, 332, J Pr Chem LI, 451.

and chloroxide gas both tedious and expensive, and that by means of iodine and chlorine or chlorate of potassa too delicate to admit of its application on the large scale. With regard to the latter method, he contests the statement of Milloⁿ(1), that in the action of aqueous chlorate of potassa on iodine, a small addition of nitric acid materially assisted the oxydation of the iodine; he considers, on the contrary, this addition as perfectly needless. He recommends, besides, when decomposing iodate of baryta by sulphuric acid, previously to diffuse the former in 15 parts of water, and to add $\frac{1}{10}$ its weight of nitric acid in order to effect a complete decomposition of the iodate by the quantity of sulphuric acid, necessary according to theory, and which is to be added in small portions; he draws attention on the circumstance, that sulphuric acid is not precipitated by baryta in presence of certain quantities of iodic acid and iodate of baryta. The best method for preparing iodic acid is, according to him, to oxydize iodine by nitric acid; he recommends to treat 5 parts of dry iodine with 200 of nitric acid of 1.5 spec. grav. in a flask, during one hour, at 60°, to separate the iodic acid formed from the supernatant layers (the upper containing nitric and hyponitric acids, the lower one a reddish-brown solution of iodine in nitric acid), to concentrate these liquid layers to $\frac{1}{3}$ by distillation, and to evaporate the residue, along with the crystallized iodic acid obtained at a low temperature and protected from the light, when anhydrous iodic acid is obtained in form of white crystals of a mother-of-pearl lustre. He farther states, that iodic acid produces, with sulphuric acid and sulphate of protoxide of iron, the same colour as nitric acid; that by the action of sulphurous acid upon a solution of iodate of baryta, no sulphate of baryta is formed; and that the atomic weight of iodine is to be assumed as = 125.6.

Iodide of Phosphorus.—Corenwinder(2) has investigated the compounds of iodine with phosphorus, to prepare which he used bisulphide of carbon as a solvent; he recommends this substance in general for the preparation of several compounds of phosphorus and iodine; thus, sulphide of phosphorus crystallizes in small, yellowish-white, easily-fusible crystals from a strongly cooled mixture of the solutions of sulphur and phosphorus in bisulphide of carbon; on saturating with chlorine a solution of phosphorus in bisulphide of carbon, and cooling, distinct white crystals of pentachloride of phosphorus, PCl_5 , are obtained, whilst on addition of phosphorus to bisulphide of carbon, previously saturated with chlorine, a powerful reaction and evolution of light ensue.—From a solution of equal equivalents of iodine and phosphorus in bisulphide of carbon, red needles of the compound PJ_2 crystallized at 0°. This compound

(1) Ann. Ch. Phys. [3] IX, 400; Berzelius' Jahresber. XXIV, 76.

(2) Ann. Ch. Phys. [3] XXX, 242; Ann. Ch. Pharm. LXXVIII, 76; Compt. Rend. XXXI, 172 (in abstr.); Instit. 1850, 249; J. Pr. Chem. LI, 159.

Iodide of
phospho-
rus.

is however better prepared by dissolving 1 equiv. of phosphorus in bisulphide of carbon, adding 2 equivs. of iodine and cooling the solution, which is at first reddish-brown, but soon becomes orange-coloured; long, flexible, orange-coloured, flat prisms are formed, which may be freed from the adhering bisulphide of carbon by a current of dry air without suffering decomposition. This compound melts at about 110° ; it is decomposed by contact with water into hydriodic and phosphorous acids, whilst yellow flakes are deposited. To prepare hydriodic acid, Corenwinder recommends to heat this compound with very little water; some phosphoretted hydrogen is mixed with the hydriodic acid. If the iodide of phosphorus, PJ_2 , be mixed with an excess of phosphorus, the latter separates on addition of water in the form of the red modification; to prepare red phosphorus, some iodine is to be added to a solution of ordinary phosphorus in bisulphide of carbon, and the whole left to evaporate spontaneously; the residue is then to be decomposed by means of water, and the white modification of phosphorus, still contained in it, to be extracted by means of bisulphide of carbon. Red phosphorus also separates, according to Corenwinder, when a solution of ordinary phosphorus in bisulphide of carbon is exposed to the action of sunlight during several days.—In order to obtain crystals from a solution of 1 equiv. of phosphorus and 3 equivs. of iodine in bisulphide of carbon, it is to be evaporated considerably; the air being excluded, and then cooled in a mixture of ice and common salt; dark red, six-sided tablets are formed, which can be completely deprived of bisulphide of carbon only by passing air from 50° to 60° over them. By fusing the substance thus purified, the compound PJ_3 is obtained in large prisms, which fuse somewhat under 55° , boil at a higher temperature whilst iodine volatilizes, are immediately changed on exposure to moist air, and are decomposed by water, hydriodic and phosphorous acids, and orange-coloured flakes being formed.—Other compounds of iodine and phosphorus could not be prepared; from solutions containing more than 3 equivs. of iodine for 1 equiv. of phosphorus, first iodine crystallizes, and then the compound PJ_3 .

Chlorine.—Barreswil(1) observed a copious disengagement of chlorine on roasting a mixture of sulphate of protoxide of iron and chloride of sodium in the air below a red heat.

On the action of chlorine on protochloride of manganese, and on chloride of lead in the presence of the chlorides of the alkali-metals, *see manganese and lead*.

Chlorates.—Calvert(2) has communicated experiments on a more productive method for preparing chlorates, especially chlorate of

(1) J. Pharm. [3] XVII, 443.

(2) Chem. Soc. Qu. J. III, 106; Chem. Gaz. 1850, 106; Compt. Rend. XXX, 656 (in abstr.); Instit. 1850, 188; Arch. Ph. Nat. XIV, 221.

potassa. The chlorates of lime and baryta were easily obtained by passing chlorine through boiling milk of lime, or through boiling water containing carbonate of baryta in suspension; (at low temperatures hypochlorites were formed). The chlorates thus obtained can, however, only with difficulty be purified from the chlorides formed at the same time. From 100 parts of solution of potassa of 1.110 spec. grav. (containing 10.233 potassa) 22 chlorate of potassa were obtained (the theoretically largest possible quantity would be 26.6 parts), by adding 358 lime (6 CaO to 1 KO), heating to 50°, and passing a rapid current of chlorine through it until saturated, then filtering, evaporating and recrystallizing the residue; the temperature rose to 90° whilst the chlorine passed through the liquid. He recommends this method for the manufacture(1) on the large scale. At the ordinary temperature but little chlorate of potassa was formed. On using more dilute solutions of potassa, the lime added being always in the proportion of 6 CaO to 1 KO, the amount of chlorate of potassa obtained was also smaller.

For the purpose of demonstrating the phenomenon of combustion by means of chlorate of potassa, Vogel, Jun.(2) proposes to pour an essential oil (the best for the purpose is oil of turpentin) on some chlorate of potassa in a wine-glass, and to add a few drops of concentrated sulphuric acid, when sudden inflammation ensues. Alcohol, ether, bisulphide of carbon (with considerable spattering), and fatty oils (best when used in small quantities and a little warmed), may also be ignited in this manner.

Hydrochloric Acid.—According to Kemp(3), hydrochloric acid is obtained free from iron, even when the mixture of chloride of sodium and sulphuric acid contains much iron and sesquioxide of iron, if 2 equivs. of sulphuric acid be used for every equiv. of chloride of sodium, and too great a degree of heat be avoided.—In order to prove that this proportion of chloride of sodium and sulphuric acid is advisable, an experiment has been proposed by Bolley(4), showing that hydrochloric acid and hydrated sulphate of soda form bisulphate of soda and chloride of sodium; on pouring hydrochloric acid of commerce upon finely-divided Glauber's-salt, the mass soon assumes a milky appearance, owing to chloride of sodium being separated in the form of small grains.

Chloride of Sulphur.—Wöhler(5) has communicated experiments on the deportment of subchloride of sulphur (S_2Cl) with metals and

(1) Calvert does not mention that Liebig has previously recommended for the purpose of preparing chlorate of potassa, to saturate a mixture of 1 equiv. KO and 6 equivs. CaO with chlorine (Ann. Ch. Pharm. XLII, 307).

(2) Ann. Ch. Pharm. LXXIV, 114; Repert. Pharm. [3] V, 339.

(3) Proceedings of the Royal Society of Edinburgh. II. 299.

(4) Ann. Ch. Pharm. LXXV, 241.

(5) Ann. Ch. Pharm. LXXIII, 374.

Chloride
of sulphur.

metallic sulphides. Coarsely powdered arsenic, covered with subchloride of sulphur in a retort, becomes rapidly heated to the boiling and distilling of the latter; by pouring back the distillate to the residue and applying heat, all the subchloride of sulphur may be decomposed, pure chloride of arsenic distilling over whilst the sulphur of the chloride of sulphur remains behind along with the excess of arsenic used. Bi- and ter-sulphide of arsenic, even in their fused state, decompose the subchloride of sulphur with the same facility and with spontaneous evolution of heat, chloride of arsenic being formed.—Antimony and black sulphide of antimony exhibit a perfectly analogous behaviour.—The action of tin- filings on chloride of sulphur is the most violent; if the distillate of this reaction, still containing undecomposed subchloride of sulphur, be again brought into contact with tin, pure bichloride of tin distils over. Bisulphide of tin is not acted upon by subchloride of sulphur, and zinc, iron, nickel and copper but little so, and slowly.

Oxychloride of Sulphur.—Millon(1) has discovered a new compound of sulphur, chlorine and oxygen. It is formed on putting a few drops of chloride of sulphur into a bottle which is not quite dry, and filled with moist chlorine-gas, when the new compound is immediately deposited on the sides of the vessel in form of colourless crystals. This compound may be obtained in larger quantities by the following method. From 20 to 30 grammes of chloride of sulphur, saturated with chlorine, are put into a bottle of 4 or 5 litres, filled with moist chlorine-gas, and 2 or 3 grammes of water added; the bottle, surrounded by a frigorific mixture, is then shaken during four or five hours; a considerable quantity of hydrochloric acid is given off; the bottle is then again filled with moist chlorine-gas, and the above process repeated until the chloride of sulphur is entirely converted into a crystalline mass. The formation of the crystals, which have sometimes the form of fine needles, sometimes that of broad rhombic tablets, is in most cases preceded by that of a yellow oil, heavier than chloride of sulphur. The crystals can be freed from chloride of sulphur and some sulphuric acid formed with them, in the following manner only (and even so, not completely): a current of dry chlorine-gas is passed through the bottle for ten or twelve hours, and the crystals themselves shifted about in the bottle by the application of heat. The substance thus obtained is decomposed with great violence by water, alcohol and dilute acids; sealed up in a glass tube, it is transformed after a few months into an isomeric compound, forming a very mobile liquid of slightly yellow colour, not solidifying at -18° , and which is but slowly decomposed by water, alcohol and dilute acids, sulphuric, sulphurous and hydrochloric acids being formed. The analysis of the liquid compound showed its composition to be

(1) Ann. Ch. Phys. [3] XXIX, 237; J. Pr. Chem. L, 267; Ann. Ch. Pharm. LXXVI, 235.

$=\text{S}_2\text{Cl}_2\text{O}_3$, viz.: dithionic acid, in which 2 equivs. of O are replaced by 2 equivs. of Cl.

Sulphochloride of phosphorus.

Sulphochloride of Phosphorus.—Gladstone(1) has investigated the action of sulphur on pentachloride of phosphorus (PCl_5). When fused, both substances combine, and colourless crystals are formed. On application of a higher heat a yellow liquid is formed, which can be distilled over; it contains phosphorus, chlorine and sulphur, and differs from the compounds of this kind hitherto known. In order to prepare this liquid, 3 parts of pentachloride of phosphorus and 1 part of sulphur (a little more sulphur than corresponds to the proportion 1 PCl_5 : 4 S) are mixed in a small retort and gently heated to the fusing-point until the reaction has taken place throughout the whole mass; a yellow liquid and colourless crystals are formed thereby; on applying a somewhat higher heat the crystals disappear, but are formed again on cooling; on heating rapidly to boiling a liquid distils over (first at 110° , and then at a higher temperature), from which but few crystals separate, and in the retort remains (sometimes only) a small quantity of a dark-coloured, tough substance, volatile at a higher heat, which is not attacked by water, and appears to give up some chlorine when acted upon by alkalis. The crystalline and the fluid body are formed in varying proportions; of the former scarcely a trace is sometimes to be found amongst the final products of the decomposition. When less sulphur is used than stated above, some unchanged chloride of phosphorus remains in the retort, and when more is used, a mixture of sulphur with the tough body above-mentioned. No other substances than those mentioned, were observed to be formed.—The liquid compound is freed from the crystals, as much as possible, by repeated rectifications at a gentle heat, until it distils over completely at a temperature not exceeding 125° ; it then is clear, mobile, slightly yellow, of a feeble and sourish odour, possessing high refracting power, evaporating even at the ordinary temperature, boiling at about 118° , not solidifying at -17° , heavier than water; the spec. grav. of its vapour at 203° was found to be $=5.5(2)$. Its composition corresponds to the formula PCl_5S_4 ; Gladstone views it, accordingly, as a combination of pentachloride of phosphorus with 4 equivs. of sulphur, and terms it *sulphochloride of phosphorus*. When hot, this substance dissolves considerable quantities of sulphur, phosphorus and chloride of phosphorus, which again separate on cooling in a crystalline form; it dissolves iodine with a deep red colour, is miscible with bisulphide of carbon, and is not attacked by concentrated sulphuric acid, at least not when cold. It decomposes ether, alcohol and oil of turpentin with violence; it

(1) Chem. Soc. Qu. J. III, 5; Ann. Ch. Pharm. LXXIV, 88.

(2) This would indicate a very improbable condensation, viz. PCl_5S_4 to 7 volumes.

Sulphochloride of Phosphorus. is not decomposed by hydrogen, but on passing sulphuretted hydrogen over it, sulphur is deposited, a gas is disengaged in the liquid and another fluid substance remains behind. Metals decompose it, some only on application of heat; by nitric acid it is oxydised with violence. In contact with water it is instantaneously decomposed; the odour of bisulpho-terchloride of phosphorus is perceptible, and after a few hours a residue of sulphur with some sulphide of phosphorus is obtained, and a solution containing hydrochloric, sulphuric, phosphoric, probably phosphorous and another acid, which seems to be the sulpho-phosphoric acid of Wurtz (PS_2O_3)(1). In contact with aqueous solutions of alkalis, the sulphochloride of phosphorus undergoes the same decomposition as with water, only more rapidly; the liquid assumes a dark red colour before the decomposition is complete, and the sulphur which separates is, at first, mixed with orange-coloured flakes.—The crystals gradually deposited from crude sulphochloride of phosphorus (the form of which is not intelligible to us) contain phosphorus and chlorine in the proportion of 1:5, but varying quantities (as much as 16.6 per cent of sulphur); Gladstone views them as a mixture of PCl_5 and PCl_5S_4 .

Fluorine.—G. Wilson(2) has stated, that by using 24 pints of ox-blood, 12 pints of milk, and 12 lbs. of cream cheese, fluorine could very distinctly be detected in the ashes of these substances; but very minute traces were found in the ashes of 4 pints of whey. He thinks the fluoride of calcium accompanies here also the phosphate of lime. According to him, 67,000 parts of water at 15° dissolve 0.26 of fluoride of calcium.

Nitrogen. Nitride of Boron.—Balmain(3) had previously obtained compound of boron with nitrogen by heating boracic acid with cyanide of potassium, or with cyanide of zinc, or with cyanide of mercury and sulphur; he supposed it at first to be capable of uniting with metals analogous to cyanogen, and termed it *Aethogen*. Wöhler(4) found afterwards that this body may also be prepared with advantage by igniting an anhydrous mixture of borax and ferrocyanide of iron.—This compound has recently been the subject of investigation by Wöhler(5). He prepared it by intimately mixing 1 part of pure anhydrous borax with 2 parts of dry sal-ammoniac, igniting the mixture in a covered crucible of porcelain or platinum,

(1) Comp. Annual Report for 1847 and 1848, I, 275.

(2) Chem. Gaz. 1850, 366; Instit. 1850, 365.

(3) Phil. Mag. [3] XXI, 170; XXII, 467; XXIII, 71; XXIV, 191; Berzelius' Jahresber. XXIII, 98; XXIV, 82, 187; XXV, 87.

(4) Berzelius' Lehrb. d. Chem. III, 113.

(5) Ann. Chem. Pharm. LXXIV, 70; Pogg. Ann. LXXIX, 467; Ann. Ch. Phys. [3] XXIX, 240; Instit. 1850, 159.

tritulating the white, porous mass thus formed, protractedly boiling with much water and some hydrochloric acid(1), separating the nitride of boron on a filter, carefully washing it with hot water, and drying(2). The substance thus prepared contained at most 42.7 per cent of boron and 51.4 per cent of nitrogen(3). Wöhler considers the pure compound as having a composition corresponding to the formula BN, which requires 43.8 per cent of boron and 56.2 per cent of nitrogen. He thinks it probable that the preparations examined by him still contained an admixture of some boracic acid, which was protected against the action of solvents by the nitride of boron. Nitride of boron shines in the edge of a flame with a brilliant greenish-white light; foreign bodies prevent this shining. In the flame of alcohol, fed by oxygen, it undergoes rapid combustion with a greenish-white, feeble flame, and formation of vapours of boracic acid. It neither melts nor loses nitrogen when exposed during one hour to the melting heat of nickel in a crucible of porcelain, which, surrounded by charcoal, is put into a crucible of clay. It is not decomposed by ignition in an atmosphere of hydrogen, chlorine or carbonic acid gas, nor by concentrated acids or alkalis; it is, however, slowly converted into boracic acid and ammonia, when heated with concentrated sulphuric acid until the acid commences to evaporate; when digested with fuming hydrofluoric acid, much borofluoride of ammonium is formed; and when fused with hydrate of potassa, a considerable quantity of ammonia is given off. In a current of aqueous vapour, it becomes converted into ammonia and boracic acid, at a moderate red heat; the same decomposition is slowly effected, when it is heated with water in a sealed tube at 200°. On being ignited with easily-reducible metallic oxides (the oxides of lead, copper or mercury), it forms nitric oxide and nitrous acid, whilst the oxides are reduced, without however producing incandescence. When ignited with anhydrous carbonate of potassa, borate and cyanate of potassa are formed ($\text{BN} + 2[\text{KO}, \text{CO}_2] = \text{KO}, \text{BO}_3 + \text{KO}, \text{C}_2\text{NO}$). 3 parts of nitride of boron and 17 parts of carbonate of potassa, heated in a platinum crucible over the spirit-lamp, fuse, even at a low red heat, to a limpid liquor, which, on cooling, becomes a crystalline white mass, consisting of nearly equal parts by weight of borate and cyanate of potassa, and forming with water a clear solution. When

Nitro-
gen.
Nitride of
boron.

(1) The aqueous extract being slowly evaporated, chloride of sodium is obtained in distinct, clear octahedrons, which assume a milky appearance on heating.

(2) According to H. Rose (Pogg. Ann. LXXX, 265), nitride of boron is best prepared by mixing a solution of boracic acid with sal-ammoniac, evaporating to dryness, igniting the dry mass and then exhausting it with water. Nitride of boron is not formed when the dry mass is ignited in an open platinum crucible with access of air. Solution of boracic acid, evaporated with nitrate of ammonia and the residue ignited, yields no nitride of boron.

(3) The amount of boron was determined by igniting with nitrate of lead and estimating how much the weight of the fused residue exceeded that of the oxide of lead which had to remain. This excess was caused by the boracic acid formed.

Sulphide of nitrogen. an excess of nitride of boron is used, much cyanide of potassium is formed at the same time.

Sulphide of Nitrogen.—As a product of the action of ammoniacal gas in excess upon protochloride of sulphur, Soubeiran(1) observed a yellow body, which he viewed as $\text{SCl}, 2 \text{NH}_3$; cold water separates from it tersulphide of nitrogen, NS_3 . Laurent(2) assigned the formula S_2HN to the latter product.—Fordos and Gélis(3) give the following statements: The substance considered by Soubeiran as $\text{SCl}, 2 \text{NH}_3$ is a mixture from which different solvents extract 5 different bodies. Bisulphide of carbon withdraws from it sulphur and an orange-coloured substance. When the mixture is deprived of its sulphur by repeated treatments with cold bisulphide of carbon, and the residue repeatedly boiled with bisulphide of carbon, the orange-coloured substance is completely extracted, and obtained in a crystalline form on evaporation; it agrees in most of its properties with the substance which Soubeiran designated as sulphide of nitrogen. It crystallizes in transparent, rhomboidal prisms; its powder has a bright golden hue, possesses a faint odour, and strongly irritates the mucous membrane. In this substance Fordos and Gélis found unessential and varying amounts of hydrogen, 68.83 to 69.95 per cent of sulphur, and 30.38 to 31.01 per cent of nitrogen, corresponding to the formula NS_2 . This bisulphide of nitrogen explodes when struck, and also when heated in a tube to 157° ; on being touched with an ignited body, it burns without detonation. It is but little soluble in alcohol, ether, wood-naphtha, and oil of turpentin; the solution in bisulphide of carbon gradually decomposes, when it becomes decolorized, and sulphur, hydrocyanic acid, and a yellow precipitate of the appearance of sulphocyanogen, are formed. Water scarcely wets bisulphide of nitrogen, and does not dissolve it; it becomes however gradually decomposed by it, ammonia is given off, and hyposulphurous and trithionic acids are formed ($4 \text{NS}_2 + 15 \text{HO} = \text{NH}_4 \text{O}, \text{S}_2 \text{O}_5 + 2 [\text{by } \text{NH}_4 \text{O}, \text{S}_3 \text{O}_5] + \text{NH}_3$); bisulphide of nitrogen is decomposed potassa, hyposulphurous and sulphurous acids being formed ($2 \text{NS}_2 + 3 \text{KO} + 6 \text{HO} = \text{KO}, \text{S}_2 \text{O}_2 + 2 [\text{KO}, \text{SO}_2] + 2 \text{NH}_3$).

Chlorophosphide of Nitrogen.—Liebig and Wöhler(4) discovered, in the course of their investigations on the compounds of phosphorus and nitrogen, a crystalline substance, containing chlorine, phosphorus and nitrogen, the composition of which corresponded to the formula $\text{P}_3\text{N}_2\text{Cl}_5$. Gladstone(5) has submitted

(1) J. Pharm. [2] XXIV, 49; Berzelius, Jahresber. XVIII, 175.

(2) Annual Report for 1849, III, 175; Laur. and Gerh. C. R. 1850, 208 (in detail).

(3) Compt. Rend. XXXI, 702; Instit. 1850, 369; J. Pharm. [3] XIX, 5; Ann. Ch. Pharm. LXXVIII, 71.

(4) Ann. Ch. Pharm. XI, 139.

(5) Chem. Soc. Qu. J. III, 135; Ann. Ch. Pharm. LXXVI, 74; Laur. and Gerh. C. R. 1850, 382.

this body to a closer examination. He had found(1) already, in a former investigation, that chloro-phosphide of nitrogen is always formed when pentachloride of phosphorus (PCl_5) is saturated with dry ammoniacal gas; it is then mixed with chloride of ammonium and the chloro-phosphamide of Gerhardt, and can be extracted from this mixture either by means of ether (whereby, however, decomposition easily ensues, vide p. 196), or by violently boiling it with water in a retort, when the chloro-phosphide of nitrogen is volatilized with the vapours of water, and is deposited in a pure state in the neck of the retort. The preparation of the chloro-phosphide of nitrogen is more expeditious, according to the method discovered by Liebig, in which the vapour of chloride of phosphorus acts upon heated chloride of ammonium. For this purpose, Gladstone half fills a bottle with a mixture of 1 part of chloride of phosphorus and 2 parts of well-dried chloride of ammonium, and connects it with two or more receivers, the first of which is dry and kept cold, whilst the others contain water; on applying heat, the mixture first assumes a red, and then a brown colour; chloro-phosphide of nitrogen sublimes, in the first receiver a clear liquid (sometimes with some white, solid substance) condenses, and in the water of the last receiver hydrochloric acid and some chloro-phosphide of nitrogen are collected. The clear liquid in the first receiver is oxychloride of phosphorus, PCl_3O_2 (accidentally formed through presence of moisture), which is saturated with hydrochloric acid, and contains some chloro phosphide of nitrogen in solution. The quantity of chloro-phosphide of nitrogen obtained by this decomposition amounts to only about 6 per cent of the chloride of phosphorus employed.—Chloro-phosphide of nitrogen, when sublimed, forms rhombic crystals, the acuter angle of which is between 48° and 49° , and is frequently truncated; it exhibits the same form, when crystallized from alcohol, or from a mixture of alcohol and ether; when crystallized from ether, it is obtained in the form of six-sided pyramids, with angles of 132° and 114° at the basis. It fuses at about 110° to a clear liquid, boiling at about 240° . Crystallized chloro-phosphide of nitrogen possesses a somewhat higher spec. grav. than water; when fused, a lower one. It evaporates but slowly at the ordinary temperature, and yields, when heated, a dense vapour of a peculiar odour. In his analyses, Gladstone found 26.5, 26.0, 26.6, 30.1, 31.7 per cent of phosphorus; 10.6, 9.2 per cent of nitrogen; 58.8, 58.5, 59.0 per cent of chlorine; from which he likewise deduces the formula $\text{P}_3\text{N}_2\text{Cl}_6$, requiring 31.8 per cent of phosphorus, 9.3 nitrogen, and 58.9 chlorine.—Chloro-phosphide of nitrogen is insoluble in water, which wets it with difficulty only; it dissolves in alcohol (the solution has a bitter taste), ether, bisulphide of carbon, oil of turpentin, benzol, and other hydrides of carbon. When sublimed in hydrogen or

(1) Annual Report for 1849, III, 175.

Chloro-
phosphide
of nitro-
gen.

sulphuretted hydrogen it is not decomposed, nor when heated with iodine. Nitric acid attacks crystallized chloro-phosphide of nitrogen when fuming acid at a higher temperature; more easily, however, when this substance is dissolved in alcohol or in oil of turpentin. It suffers decomposition when its vapour is passed over chromate of lead or metallic oxides; when it is heated with silver, chloride of silver is formed, besides ammonia, and another salt insoluble in nitric acid. Chloro-phosphide of nitrogen is decomposed by silver also in its ethereal solution, chloride of silver and the above-mentioned insoluble salt being formed while the solution assumes an acid reaction. On mixing an alcoholic solution of the chloro-phosphide of nitrogen with nitrate of silver, chloride of silver is precipitated.

Chloro-phosphide of nitrogen, in alcoholic solution, is immediately decomposed on adding potassa or ammonia; if the liquid be now evaporated to dryness, the residue dissolved in water and neutralized, a solution is obtained which yields no precipitates with most metallic salts; when heated, however, it forms with the salts of sesquioxide of iron a white flocculent precipitate, insoluble in dilute acids; but soluble in ammonia, with a red colour. Gladstone term this precipitate nitrophosphate of iron; it is amorphous, and when dried at 70° , or at the ordinary temperature *in vacuo*, its composition is $\text{Fe}_2\text{O}_3, \text{P}_2\text{NO}_5 + 5\text{HO}$; it loses 1 equiv. of HO at 100° , and, even when previously dried at 220° , assumes a dark-brown colour on being heated to 330° , and suddenly disengages aqueous vapour and ammonia, whilst a white crystalline body sublimes, which is soluble in water. This solution yields, with nitrate of silver, a precipitate which is at first white, then shortly afterwards becomes orange-coloured, and is at last transformed into a black mass, consisting apparently of reduced silver. Nitrophosphate of iron is again precipitated from its ammoniacal solution by the addition of an acid. When the ammoniacal solution is evaporated in the water-bath, a dark red amorphous mass is obtained, which partly reproduces with water the original solution, whilst red scales remain undissolved, apparently sesquioxide of iron (vide p. 195). The nitrophosphate of iron is the only salt of this acid which is precipitated from very acid solutions; the other salts are less easily obtained in a pure state. The alumina-salt, corresponding to that of the sesquioxide of iron, is precipitated in the form of white flakes only on boiling, when the aqueous solution of the product of decomposition of the chloro-phosphide of nitrogen by alcohol and ammonia is slightly acidulated, and solution of alum is added. In like manner, a blue flocculent salt of oxide of copper is formed, when sulphate of copper is used; when it is dried at 100° , its formula is $3\text{CuO}, \text{P}_2\text{NO}_5 + 5\text{HO}$. On adding nitrate of silver in excess to an aqueous solution of the product of decomposition of chloro-phosphide of nitrogen by alcohol and ammonia, separating the chloride of silver formed, and boiling,

the filtrate, a white precipitate is obtained. This is also formed by decomposing the salt of the sesquioxide of iron with potassa in the cold, neutralizing the liquid with nitric acid, and precipitating with nitrate of silver; when it is dried between 100° and 160° , its composition is expressed by the formula $3 \text{AgO}, \text{P}_2\text{NO}_5 + 5 \text{HO}$. By the latter process, the baryta-salt was obtained in white flakes, which, when dried at 150° , were $3 \text{BaO}, \text{P}_2\text{NO}_5 + 2 \text{HO}$. The potassa-salt was obtained by Gladstone in the form of a gummy mass, though not quite pure, by decomposing the salt of the sesquioxide of iron with potassa, the former remaining in excess, and by evaporating the liquid *in vacuo* over sulphuric acid.—Besides these, Gladstone prepared several other salts. All those of the heavy metallic oxides form white flocculent precipitates; only the cobalt-salt is faintly red. The ammonia-salt, prepared from the lead-salt in a similar manner to the potassa-salt, forms a tough mass.—On treating the silver-salt with dilute hydrochloric acid, and evaporating the liquid, the free acid is obtained as a semi-solid, uncrystalline mass, deliquescent in moist air, soluble in alcohol, and of an acid reaction; it can be strongly heated, without suffering decomposition.

Chloro-phosphide of nitrogen.

Laurent(1) questions the correctness of Gladstone's formulæ. Formation and composition of the chloro-phosphide of nitrogen follow from the equation $\text{PCl}_5 + \text{NII}_3 = \text{PNCl}_2 + 3 \text{HCl}$; and that of the acid, designated by Gladstone as nitrophosphoric acid, from the equation $2 \text{PNCl}_2 + 12 \text{HO} = \text{P}_2\text{H}_5\text{NO}_{12} + 4 \text{ClH} + \text{NH}_3$. The latter acid was *pyrophosphamic acid*, and the composition of its salts expressed by the formula $\text{P}_2\text{H}_2\text{Me}_3\text{NO}_{12}$ ($= 3 \text{MeO}, \text{P}_2\text{NC}_7 + 2 \text{HO}$). The pyrophosphamic acid was probably, however, not the immediate product of the action of alkalis upon the chloro-phosphide of nitrogen, but most likely phosphamic acid (PH_4NO_6), which, by boiling, was transformed into pyrophosphamic acid, with formation of ammonia ($2 \text{PH}_4\text{NO}_6 = \text{P}_2\text{H}_5\text{NO}_{12} + \text{NII}_3$).

Gladstone states, in a second paper(2) on the products of decomposition of chloro-phosphide of nitrogen, that he does not concur with this opinion of Laurent, and adds the following data concerning nitrophosphoric acid. The nitrophosphate of the sesquioxide of iron is soluble in ammonia. The compound thus obtained is decomposed when evaporated in the water-bath (vide p. 194), but when it is evaporated *in vacuo* over sulphuric acid a deep-red mass is obtained completely soluble in cold water, forming a red, neutral liquid, for the composition of which Gladstone, according to his experiments, gives as the most probable formula, $\text{Fe}_2\text{O}_3, \text{P}_2\text{NO}_5 + 3 \text{NH}_4\text{O}$

(1) Compt. Rend. XXXI, 356; Laur. and Gerh. C. R. 1850, 387 (in detail).

(2) Chem. Soc. Qu. J. III, 353; Ann. Ch. Pharm. LXXVII, 314; Laur. and Gerh. C. R. 1851, 30 (in abstr.) In the latter place, Gerhardt persists in the above view of Laurent, and observes, "Gladstone's deuto-nitrophosphoric acid might be the phosphamic acid; inasmuch as Gladstone's formula for the former acid was highly improbable."

Chloro-
phosphide
of nitro-
gen.

+ 5 HO.—He has farther investigated the spontaneous decomposition of chloro-phosphide of nitrogen in its solution in alcohol and ether. When the white mass, obtained by the action of ammonia upon pentachloride of phosphorus, PCl_5 , is treated with ether, for the purpose of separating the chloro-phosphide of nitrogen, and the solution is evaporated, chloro-phosphide of nitrogen is obtained of a reddish or red colour, and of an odour of hydrochloric acid; on adding water, an oily body appears; the aqueous solution has an acid reaction, and when it is evaporated, and the hydrochloric acid driven off, a semi-crystalline acid mass is left, soluble in water, but nearly insoluble in alcohol. This proceeds from the circumstance that ordinary ether gradually decomposes the chloro-phosphide of nitrogen. Anhydrous ether exerts, however, no such influence, and retains the chloro-phosphide of nitrogen unchanged in solution. The decomposition by ordinary ether proceeds more rapidly on heating, hydrochloric acid, an aromatic liquid insoluble in water, and an acid, being formed. Gladstone calls the latter *deuto-nitrophosphoric acid*. The action of alcohol is a similar one, hydrochloric acid and the aromatic liquid are however the only products of this decomposition. Water alone also decomposes the chloro-phosphide of nitrogen, although very slowly, deuto-nitrophosphoric acid and hydrochloric acid being formed.—The deuto-nitrophosphoric acid crystallizes in the form of feathery crystals; on boiling it with baryta-water, or dilute solution of potassa, no ammonia is disengaged, and its neutral solution yields no precipitates with metallic oxides, in this respect, Gladstone's statements appear to be contradictory. Oxidizing agents exert but little influence upon this acid, it is dissolved by concentrated sulphuric acid in the cold, without undergoing decomposition. The crystallized acid does not lose in weight when dried at 100° , but, when it is exposed to a higher temperature, an ammonia-salt, containing phosphorus, first escapes, then free ammonia and nitrophosphoric acid remains behind. It is not precipitated by sulphate of sesquioxide of iron, but on boiling the mixture, nitrophosphate of iron is immediately formed. On boiling a neutralized solution of the acid with a metallic salt, the nitrophosphate of the metallic oxide is gradually precipitated; the above-mentioned method (p. 194) of preparing the nitrosulphates, is based upon this deportment. Gladstone has not analysed the free deuto-nitrophosphoric acid; its formula is, according to him, $\text{P}_3\text{N}_2\text{O}_5$, based upon the supposition of its being formed by the action of potassa (or water) upon chloro-phosphide of nitrogen, as shown in the equation $\text{P}_3\text{N}_2\text{Cl}_5 + 5 \text{KO} = \text{P}_3\text{N}_2\text{O}_5 + 5 \text{KCl}$; it is, according to him, tribasic. The solution of this acid is precipitated by a concentrated solution of baryta, and more so after being neutralized with ammonia; the precipitate is soluble in a large excess of ammonia. This baryta-salt showed a very varying composition; dried at 100° , it gave from 46 to 55 BaO, 11 to 22 P, 1 to 5 N, 1 H. Gladstone considers the pure

salt to have the formula $3 \text{BaO}, \text{P}_3\text{N}_2\text{O}_5 + 3 \text{HO}$. The ammonia-salt is obtained, mixed with chloride of ammonium, on decomposing chloro-phosphide of nitrogen by an alcoholic solution of ammonia. Gladstone attempted to estimate the quantity of deuto-nitrate of ammonia thus formed by determining the weight of the mixture of both salts obtained from a known weight of chloro-phosphide of nitrogen, and calculating the amount of chloride of ammonium therein; he finds this quantity to agree approximatively with that required by the formula $3 \text{NH}_4\text{O}, \text{P}_3\text{N}_2\text{O}_5 + 3 \text{HO}$. On adding ammonia to a concentrated solution of nitrophosphoric acid, the ammonia-salt immediately separates in a crystalline form; it is deliquescent in moist air. A solution of the acid, nearly neutralized with potassa, yielded with nitrate of silver a white flocculent precipitate, containing 53.2 per cent of silver.—The aromatic liquid (p. 196), formed by the decomposition of the chloro-phosphide of nitrogen with alcohol, appears to be decomposed when subjected to distillation; Gladstone considers it as the ether of deuto-nitrophosphoric acid.—He views the three tribasic acids—phosphoric acid, nitrophosphoric acid, and deuto-nitrophosphoric acid—as members of one series: PO_5 ; $(\text{PN}) \text{PO}_5$; $(2 \text{PN}) \text{PO}_5$.

Chloro-phosphide of nitrogen.

Atmospheric Air.—Lewy(1) found in his researches on the composition of the atmosphere at Santa-Fe de Bogota, that there was in 10,000 volumes of air, during the months of March to July, 1850, not more than from 3 to 4 volumes of carbonic acid; but during August and September as much as 47 volumes. The air collected by himself on the surface of the sea, he found to contain more carbonic acid and oxygen in the daytime than at night, and this difference was more marked when the sky was clear than when clouded. He found, for instance, by means of the eudiometer of Regnault(2), the composition of the air (in volumes) to be as follows:

	Oxygen.	Nitrogen.	Carbonic acid.
<i>A.</i>	21.05973	78.88637	0.0005390
<i>B.</i>	20.96084	79.00660	0.0003336

A was collected on December 18th, 1847, at 3 P.M., in $21^\circ 9'$ N. Lat., and $42^\circ 52'$ W. Long. (of Paris?); and *B* on December 4th, 1847, at 3 A.M. in 47° N. Lat. and 13° W. Long.

The cause of these differences may be, as Lewy suggests, that the heating of the surface of the sea by the sun's rays effects a disengagement of the air absorbed by the water, and which is known to be richer than the atmospheric air in oxygen.

Laskowsky(3) has examined the composition of the atmospheric air at Moscow during the cholera epidemic, from November 3rd to

(1) Compt. Rend. XXXI, 725; Instit. 1850, 371; Ann. Ch. Pharm. LXXVIII, 123; J. Pr. Chem. LII, 278.

(2) Annual Report for 1849, III, 390.

(3) Ann. Ch. Pharm. LXXV, 176.

Atmo-
spheric
air.

11th, 1847, after the method of Brunner, (by passing the air over phosphorus, when the oxygen is estimated by weight, and the nitrogen by volume.) In 14 experiments he found in the air 22.92 to 23.10 per cent by weight (20.73 to 20.89 per cent by volume) of oxygen, mean 23.02 per cent by weight (20.82 by volume). A connection between the composition of the atmosphere and the appearance of the epidemic did not exist.

Horsford(1) estimated the amount of ammonia contained in the atmospheric air from July 3rd to December 29th, (1849 ?) by passing from 36,000 to 360,000 cubic centimeters of dried air over asbestos moistened with hydrochloric acid, washing the asbestos with water and determining the ammonia in the liquor used for washing, taking into account the ammonia contained in the reagents employed. He found in 1,000,000 parts of air from 47.6 to 1.2 of ammonia (corresponding to from 134.8 to 4.2 of neutral carbonate of ammonia). The amount of ammonia was found to be largest in July and smallest in December.—Horsford(2) found no difference in the amount of ammonia contained in the atmosphere of an open space on the coast near Boston whilst east wind prevailed, and in that of a space in Boston remarkable for its dense population and filth. The organic matter of the atmosphere cannot be condensed, according to him, by means of hydrochloric acid, but by caustic potassa, this latter substance being blackened on ignition after air had passed through it.

Ammonia.—Mulder(3) has given an account of some experiments, according to which ammonia is formed when atmospheric air and sulphuretted hydrogen together between 30° and 40° come into contact with a porous substance, moistened with hydrochloric acid (such as charcoal or pumice-stone, previously boiled with hydrochloric acid and water, and then ignited); the sulphur of the sulphuretted hydrogen is said to be oxydized and the hydrogen in the nascent state to unite with the nitrogen of the air to form ammonia. From 10 cubic centimeters of air, after an action of three to four hours, there was obtained 0.05 grms. of ammonia which was estimated in the aqueous extract of the charcoal in the form of ammonio-chloride of platinum.—Fleitmann(4) passed during two days from 15 to 18 cubic decimeters of air and a somewhat smaller quantity of sulphuretted hydrogen over charcoal, previously boiled and then moistened with hydrochloric acid; the aqueous extract of the charcoal after the dissipation of the sulphuretted hydrogen evaporated with bichloride of platinum left,

(1) Ann. Ch. Pharm. LXXIV, 243; for former determinations of the amount of ammonia contained in air, see Annual Report for 1849, III, 174.

(2) Proceedings of the 2 American Association for the Advancement of Science, held at Cambridge, August, 1849, 124.

(3) Scheik Onderz. V, 7 Stuk, 404; J. Pr. Chem. L, 431; Repert. Pharm. [3] VI, 179.

(4) Ann Ch Pharm LXXVI, 127.

when treated with absolute alcohol, scarcely appreciable traces of a yellow platinum-salt, and consisted chiefly of gypsum. Ammonia

Griffin(1) has described, under the name of *ammoniameter*, a hydrometer for the purpose of estimating the amount of ammonia in liquor ammoniæ, and has published a table showing the relation between specific gravity and the amount of ammonia contained in such liquids. We extract the following data, valid for 16°·7 C. (62° F.) *A* signifies the spec. grav., *B* the amount of ammonia in per cents by weight:

<i>A</i>	<i>B</i>	<i>A</i>	<i>B</i>	<i>A</i>	<i>B</i>
0·875	34·96	0·925	19·69	0·975	6·23
0·885	31·56	0·935	16·88	0·985	3·70
0·895	28·49	0·945	14·14	0·995	1·22
0·905	25·49	0·955	11·44	1·000	0·00
0·915	22·56	0·965	8·81		

Laurent(2) has given a more extended statement of his views on the constitution of the compounds formed by the action of ammonia upon other substances. We have already mentioned these views in our last year's Report(3), according to an abstract previously published, and must again desist from entering more fully upon these diffuse considerations, rarely supported by experiments of his own, on the composition of a large number of compounds.

Chloride of Ammonium.—Köllner(4) obtained crystals of the form of quadratic trapezohedrons in the manufacture of sal-ammoniac from the ammoniacal liquor obtained during the manufacture of coal-gas, the principal contents of which are carbonate of ammonia and sulphide of ammonium, with traces of cyanide of ammonium. This liquor was decomposed by chloride of calcium, the filtrate saturated with hydrochloric acid, evaporated to dryness and heated, in order to destroy organic admixtures; the residue was then dissolved in water, the solution mixed with a liquor(5) containing sulphide of ammonium with a little carbonate and free ammonia, besides traces of cyanide of ammonium; it was then heated to boiling, filtered, and hydrochloric acid added until it assumed a strong acid reaction, and was finally left to crystallize. Erdmann(6) found these crystals to be nearly free from impurities, containing besides chloride of ammonium, merely traces of free hydrochloric acid and sulphate of lime.—Naumann(7) recognized these apparent quadratic trapezohedrons as distortions of regular forms, arising from a partial development of the faces. They are formed when those eight faces of an ikositetrahe-

(1) Chem. Soc. Qu. J. III, 206; Pharm. J. Trans. X, 413.

(2) Laur. and Gerh. C. R. 1850, 201.

(3) Annual Report for 1849, III, 175.

(4) J. Pr. Chem. L, 18.

(5) Obtained by collecting in solution of ammonia the gas given off on the addition of hydrochloric acid to the gas-liquor previously precipitated by chloride of calcium and separated from the precipitate thus formed.

(6) J. Pr. Chem. L, 20.

(7) J. Pr. Chem. L, 11.

Chloride of
ammonium.

dron only are developed which are situated alternately on the upper and lower half of the crystals, the crystal being considered to stand perpendicularly with an octahedral axis, and divided horizontally into two parts through its centre. Some of the crystals are distortions of this character of 3 O 3 (two opposite faces of a terminal angle have then an inclination of $35^{\circ} 8'$), others of $\frac{3}{4}$ O $\frac{3}{4}$ (when this inclination amounts to 41°); frequently hemimorphism is also met with, the upper portion of the crystal belonging to one form, the lower to the other. Besides these, there have been observed single faces of 2 O 2 as truncatures of the terminal edges of the trapezohedron of 3 O 3, and as pointing the terminal angles.—Other forms of the chloride of ammonium have been observed by Naumann(I) in crystals which were accidentally obtained by Wöhler on decomposing euchronate of ammonia by hydrochloric acid. These crystals are rhombohedrons with angles of the terminal edges of $67^{\circ} 7'$, formed by the exclusive development of 6 faces of the ikositetrahedron 4 O 4; their terminal edges are pointed by a scalenohedron, formed by 12 faces of the tetrakisshexahedron ∞ O 3.

Potassium. Nitrate of Potassa.—Longchamp(2) has made communications, chiefly in a historical point of view, on the formation of saltpetre in nature, and on the artificial production of this salt.

A violent explosion, which occurred in the year 1845, in New York, through fire, in a large warehouse filled with saltpetre and combustible substances, induced Hare(3) to investigate, under what circumstances fusing saltpetre can produce an explosion (not merely a deflagration) with combustibles; he found that it takes place whenever perfect contact is made of the two substances, by a violent stroke or by the falling of a large mass of the combustible substance upon the fusing saltpetre.

Sodium. Carbonate of Soda.—Jacquelin(4) has produced, according to a brief notice, two new compounds of water and carbonate of soda, viz.: $\text{NaO}, \text{CO}_2 + 9 \text{H}_2\text{O}$ and $\text{NaO}, \text{CO}_2 + 15 \text{H}_2\text{O}$; he states that carbonate of soda gives off carbonic acid when fused, even in a stream of pure and dry carbonic acid gas.

Sulphate of Soda.—Loewel(5) has investigated the supersaturation of solutions of salts, first and chiefly that of water with sulphate of soda. The results obtained by him are mainly mere corroborations of former observations which Loewel appears to have only partially known(6).—Solutions of sulphate of soda in water saturated whilst hot

(1) J. Pr. Chem. L. 310.

(2) Ding. Pol. J. CXVII, 436; Rev. Scientif. Industr. XXXIII (in abstr.)

(3) Phil. Mag. [3] XXXVII, 525.

(4) Compt. Rend. XXX, 106; Instit. 1850, 41; the detailed account (Ann. Ch. Phys. [3] XXXII, 195) will be given in our Report for 1851.

(5) Ann. Ch. Phys. [3] XXIX, 62; Compt. Rend. XXX, 163 (in abstr.); Instit. 1850, 67; Arch. Ph. Nat. XIII, 288; Ann. Ch. Pharm. LXXXVI, 227.

(6) A synopsis of these former observations will be found in Gmelin's Handb. der Chem. 4th ed. I, 10.

and kept in closed vessels, do not deposit crystals during a long period between 15° and 25° , even when shaken; in lower temperatures crystals are formed, which redissolve on application of heat in the still supersaturated liquor, and which are again formed on cooling. After the opening of the vessels, or on pouring the liquor off the crystals, the whole congeals to a mass consisting of $\text{NaO}, \text{SO}_3 + 10 \text{HO}$. The above crystals are the sulphate of soda, already examined by Faraday and by Ziz, with 8 (or, according to Loewel's supposition, with 7, who leaves, however, this point undecided) atoms of water, which on exposure to the atmosphere, and still more rapidly when brought in contact with a solid body, is rendered opaque, with disengagement of heat. According to Loewel's observations, the liquor in contact with the crystals $\text{NaO}, \text{SO}_3 + 8 \text{HO}$ is supersaturated (containing more anhydrous sulphate of soda than are contained in a solution saturated at an equal temperature in contact with crystals $\text{NaO}, \text{SO}_3 + 10 \text{HO}$); the supersaturation of the former liquor remains, however, constant for equal temperatures. The following table shows the quantity of anhydrous sulphate of soda contained (*A*) in a supersaturated, (*B*) in a saturated solution at different temperatures, and for every 100 parts of water :

	0°	10°	13°	16°	17°	18°	19°	20°
<i>A</i>	19.6	30.5	34.3	38.7	40.0	41.6	43.4	44.7
<i>B</i>	5.0	9.3	11.2	14.3	15.6	16.8	18.1	19.5

Loewel is of opinion that the so-called supersaturated solutions contain the sulphate of soda $\text{NaO}, \text{SO}_3 + 8 \text{HO}$, which salt, he says, is much more soluble than $\text{NaO}, \text{SO}_3 + 10 \text{HO}$, and which can pass into the latter by the influence of other substances; *e. g.*, the contact with solid bodies.—The influence of the electric current produces no change in a supersaturated solution; there is no electricity set free during the sudden crystallization of a supersaturated solution, nor during the progress of opacity in the crystals $\text{NaO}, \text{SO}_3 + 8 \text{HO}$. The disengagement of heat, however, in both cases, has been confirmed by Loewel.—A hot saturated solution of sulphate of soda, when exposed to the air, forms crystals of $\text{NaO}, \text{SO}_3 + 10 \text{HO}$ on cooling, whenever the temperature has fallen below 32° ; when, however, the dish containing it is placed under a bell-jar, so as to render the access of air difficult, a supersaturated solution is formed, and then only at a lower temperature crystals make their appearance, having the composition $\text{NaO}, \text{SO}_3 + 10 \text{HO}$. Supersaturated solutions are also formed when the vessel in which the hot saturated solution has been made is allowed to cool whilst covered loosely, as for instance, with a dish. The crystallization of $\text{NaO}, \text{SO}_3 + 10 \text{HO}$ from a supersaturated solution is induced by contact with a rod of glass or metal, provided the latter has not been previously heated; a heated rod does not effect this induction of crystallization, and retains this quality for ten or twelve days, if it be cooled in a closed vessel; whilst it loses this property

Sulphate
of soda.

very shortly when exposed to the atmosphere. The same property is imparted to the rod by immersion in water during ten or twelve hours, and is lost again when dried in the open air. Addition of water to a supersaturated solution does not cause it to crystallize, but cold alcohol produces this effect. A layer of warm alcohol put upon the solution effects a crystallization of $\text{NaO}, \text{SO}_3 + 8 \text{HO}$ only after some time has elapsed, by depriving it of water. A drop of solution of sulphate of soda, evaporating on a rod suspended in a closed vessel and previously heated, is converted into supersaturated solution, whilst under the same circumstances a drop on a rod not previously heated forms crystals of $\text{NaO}, \text{SO}_3 + 10 \text{HO}$.—Finally, a supersaturated solution may be obtained, according to Loewel, without the co-operation of a higher temperature; a solution of 8 parts of sulphate of soda in 10 of water, made at 26° and kept for some time at that temperature, very frequently refuses to crystallize when cooled in closed vessels down to 8° or 6° , and at 0° (32°F.) deposits some crystals of $\text{NaO} + 8 \text{HO}$.

Barium.—Horsford(1) has compared the properties of the corresponding compounds of barium, strontium, calcium, and magnesium, and thinks that the intensity of their properties (degrees of solubility *e. g.*) stands generally in the same proportion as the atomic weights of these compounds.

Peroxide of Barium.—Brodie(2) has investigated the decomposition (by various substances) of peroxide of barium dissolved in dilute acids. The action of a solution of bichromate of potassa acidulated with hydrochloric acid, causes a copious disengagement of oxygen; when the solutions are cold and dilute, this is preceded by the formation of a blue compound first observed by Barreswil(3). With a large excess of the bichromate, this reaction takes place according to Brodie's experiments, after the following equation: $2 \text{CrO}_3 + 4 \text{BaO}_2 = \text{Cr}_2\text{O}_3 + 7 \text{O} + 4 \text{BaO}$, and the amount of pure peroxide, if the peroxide used contained baryta, may be calculated from the weight of the oxygen escaping. The oxide, chloride, sulphate and carbonate of silver in contact with an acid solution of peroxide of barium are partially converted into metallic silver with decomposition of the peroxide. In Brodie's experiments, always less silver was reduced than would be equivalent to the oxygen contained in the peroxide beyond BaO , and still less when sulphate of silver was used. Since definite laws cannot be deduced from these experiments, we must refer to the original paper itself for the particular results obtained by Brodie on working with quantities in different proportions and at different temperatures. Generally speaking, the amount of the silver-compound reduced was the greater the

(1) Sill. Am. J. [2] IX, 176.

(2) Loc. cit. p. 171.

(3) Annual Report for 1847 and 1848, I, 319.

larger the quantities were which had been operated upon ; and it was the smaller, the higher the temperature was. In the instances quoted above, a small quantity of the silver-compound, or of a similar substance, causes the decomposition of a considerable quantity of the peroxide of barium ; iodine, however, decomposes only its equivalent of peroxide of barium ($\text{BaO}_2 + \text{I} = \text{BaI} + \text{O}_2$).

Calcium.—O. L. Erdmann and R. F. Marchand(1) have observed that on heating calcareous spar the same phenomena appear, which, according to Marchand and Scheerer, take place in the case of magnesite (p. 204), viz. that some carbonic acid escapes on drying at 200° , and that even after the most violent ignition some carbonic acid is retained by the lime. This circumstance must have rendered the atomic weight of lime somewhat too large in former determinations, made by ignition of dried calcareous spar. In a recent experiment, and with the necessary corrections for the above circumstances, Erdmann and Marchand have found the atomic weight of lime to be $=27.99$, while their former experiments yielded numbers a little higher than 28 ; 28 has therefore to be retained as the atomic weight of lime.

Sulphate of Lime.—A. Vogel, Jun.(2) has confirmed that gypsum is more soluble in water containing chloride of ammonium than in pure water ; according to him, part of the dissolved gypsum is contained in the former solution in a decomposed state (chloride of calcium and sulphate of ammonia), and the more so the higher the temperature is at which the solution has been prepared. The presence of nitrate of potassa also increases the solubility of gypsum.

Sulphate of Lime and Potassa.—J. A. Phillips(3) has described a double salt of sulphate of lime and sulphate of potassa. In the manufacture of tartaric acid from tartar the latter is decomposed by means of carbonate of lime, tartrate of lime and neutral tartrate of potassa being formed ; by the action of sulphate of lime, all the tartaric acid is then obtained in combination with lime along with an impure solution of sulphate of potassa ; on evaporating the latter a hard deposit is formed, and on slowly cooling large quantities of the solution foliated transparent crystals are deposited, slightly soluble in water, but easily in dilute hydrochloric acid. Their composition is KO , $\text{SO}_3 + \text{CaO}$, $\text{SO}_3 + \text{HO}$, and their form, according to W. H. Miller's determination, a rhombic combination $\infty \text{P} \cdot \infty \bar{\text{P}} 2 \cdot \check{\text{P}} \infty$ with predominant faces $\infty \check{\text{P}} \infty$ (in the brachydiagonal principal section $\infty \text{P} : \infty \bar{\text{P}} = 92^\circ 56'$, $\infty \bar{\text{P}} 2 : \infty \bar{\text{P}} 2 = 153^\circ 16'$, $\check{\text{P}} \infty : \check{\text{P}} \infty = 105^\circ 56'$). The amorphous deposit contains about 65 per cent of the double salt, besides sulphate, carbonate and phosphate of lime,

(1) J. Pr. Chem. L, 237 ; Ann. Ch. Pharm. LXXVI, 219 (in abstr.)

(2) Repert. Pharm. [3] V, 342.

(3) Chem. Soc. Qu. J. III, 348.

Basic
chloride of
calcium.

carbonate of magnesia, silicate of potassa, sesquioxide of iron, alumina, water, and traces of organic matter.

Basic Chloride of Calcium.—Beesley(1) has investigated the compound of lime and chloride of calcium which separates on cooling from a filtered solution of chloride of calcium boiled with hydrate of lime. He found its composition to be $3 \text{ CaO}, \text{CaCl} + 14 \text{ HO}$. (1) Rose, in a former examination, obtained 16 equivs. of water.)

Magnesium.—The atomic weight of magnesia was lately determined by Schreerer(2) as 20·08, then as 20·11; by Svanberg and Nordenfeldt(3) as 20·36. Jacquelin(4) gives the number 20·2 as the result of a recent estimation by himself; the details of his method have not been published.—R. A. Marchand and Scheerer(5) have made an extensive series of experiments on this subject. Their method has been as follows: Ignition of native carbonate of magnesia (magnesite), free from lime; estimation of the loss caused thereby, with the necessary corrections for the admixtures of the mineral, for the amount of water still retained even after drying at 300° , for the carbonic acid escaping from the magnesite during the process of drying (even below 300°C.), and for the carbonic acid retained by the residue after ignition (even when it is ignited in Sefström's furnace for two hours). These corrections taken into account, they found from their experiments with the yellow, transparent magnesite of Snarum (containing from 0·005 to 0·02 per cent of silica and from 0·78 to 0·81 per cent of protoxide of iron) the number 20·07 for the equivalent of magnesia, from experiments with white, opaque magnesite of Snarum (containing 0·78 per cent of protoxide of iron and 0·14 per cent of silica) the number 20·06, and from experiments with selected pieces of dense magnesite of Frankenstein (containing only 0·05 per cent of impurities, viz., 0·02 silica, 0·01 alumina, 0·01 sesquioxide of iron and traces of alumina) on an average 20·03. Marchand and Scheerer consider the latter number as probably the most correct; by reducing the weighings to the vacuum, this number becomes 20·02, and they decide upon taking the equivalent of magnesia as exactly 20·0.

Salts of Magnesia.—Jacquelin(6), according to a brief notice, has discovered 3 new compounds of sulphate of magnesia: $4 (\text{MgO}, \text{SO}_3) + 7 \text{ HO}$; $4 (\text{MgO}, \text{SO}_3) + 9 \text{ HO}$; $2 (\text{MgO}, \text{SO}_3) + 5 \text{ HO}$; besides 2 new carbonates of magnesia: $5 \text{ MgO}, 4 \text{ CO}_2 + 10 \text{ HO}$ (in this only the amount of water would be new) and $6 \text{ MgO}, 5 \text{ CO}_2 + 14 \text{ HO}$ —According to Nörsgaard(7), $\text{MgO}, \text{CO}_2 + \text{HO}$ is obtained, when an excess of carbonate of soda is added to a boiling solution of sulphate of mag-

(1) *Pharm. J. Trans.* IX, 568.

(2) *Annual Report for 1847-8*, I, 302.

(3) *Annual Report for 1847-8*, I, 302. (4) *Compt. Rend.* XXX, 106; *Instit.* 1850, 41.

(5) *J. Pr. Chem.* L, 385; *Ann. Ch. Pharm.* LXXVI, 219.

(6) *Loc. cit.* page 200.

(7) From the Report of the Copenhagen Academy, 1848, 75, in *Berzelius' Annual Report*, continued by Svanberg, XXIX, 153.

nesia, and the precipitate formed is washed with boiling water; MgO , $\text{CO}_2 + 2 \text{HO}$ is obtained by precipitating an excess of sulphate of magnesia with carbonate of soda; the latter salt is said to possess a decided inclination to combine with more water.—According to Linck(1) there exists only one double salt of chloride of magnesium and chloride of ammonium, which when crystallized and dried at $100^\circ = 3 \text{MgCl}_2, \text{NH}_4\text{Cl} + 20 \text{HO}$; he states that an excess of ammonia precipitates from a solution of chloride of magnesium at the ordinary temperature, only so much magnesia that the liquor contains for every 3 equivs. of chloride of magnesium, 1 equiv. of chloride of ammonium. At 100° , one half of the magnesium is precipitated, so that the liquor contains equal equivs. of chloride of magnesium and chloride of ammonium; the liquor is however decomposed, on evaporation, into chloride of ammonium, and the above double salt:

Respecting the nitrate of magnesia, and the compounds designated as alcoholates, discrepant results have been obtained by Einbrodt(2), and by Chodnew(3). Einbrodt(4) has now published a reply to Chodnew's statements, which however does not contain any new observations; we, therefore, refer the reader to the original paper.

Aluminium. Nitrate of Alumina.—Salm-Horstmar(5) observed that crystals were formed on cooling an evaporated solution of hydrate of alumina, containing some potassa, in nitric acid of 26.3 per cent, and that ultimately the liquor entirely solidified into a mass of crystals (six-sided tables, of $\frac{1}{6}$ to $\frac{1}{4}$ of an inch diameter). This salt contained no nitrous acid, but some potassa; it readily dissolved in water and in alcohol, and deliquesced only in moist air. On evaporating a solution of the salt in a small quantity of water over sulphuric acid, or a nitric solution over potassa, it was obtained in the form of rhombic tablets of 106° and 74° ; and in six-sided tablets (formed by truncation of the more acute angle^m). After being repeatedly dissolved, the salt did not yield any farther distinct crystals; it was decomposed on evaporating the aqueous solution at a somewhat higher temperature.—According to Ordway(6), in a concentrated and somewhat acid solution of nitrate of alumina colourless, flat, oblique, rhombic prisms, $\text{Al}_2\text{O}_3, 3 \text{NO}_5 + 18 \text{HO}$, are formed, which melt at $72^\circ.8$ to a colourless liquid, solidifying on cooling to a crystalline mass; they are deliquescent, and soluble in water and in nitric acid. On mixing $\frac{1}{2}$ an ounce of the powdered crystals with

(1) Proceedings of the 2. American Association for the Advancement of Science, 235; compare the contradictory results of Hautz, in the Annual Report for 1847 and 1848, 299.

(2) Annual Report for 1847 and 1848, I, 303; II, 314.

(3) Annual Report for 1849, III, 177, 282.

(4) From the Bulletin of the Nat. Hist. Soc. of Moscow, XXIII, J. Pr. Chem. LI, 193.

(5) J. Pr. Chem. XLIX, 208.

(6) Sill. Am. J. [2] IX, 30; Chem. Gaz. 1850, 61; Ann. Ch. Pharm. LXXVI, 247.

Tung-
sten.

an equal weight of bicarbonate of ammonia, the temperature was reduced from $10^{\circ}5$ to $-23^{\circ}3$. By the action of this compound on hydrate of alumina, basic salts appear to be produced.

Tungsten.—Berzelius found the atomic weight of tungsten by reducing tungstic acid to metal = 93.90, by oxydizing metallic tungsten to tungstic acid = 95.43, mean 94.66. Recent investigations on this subject have been made by R. Schneider(1). The tungstic acid was purified (especially from iron) by continued boiling with nitro-hydrochloric acid, washing with acidulated water, dissolving in dilute ammonia, with application of heat, precipitating the solution with an excess of hydrochloric acid, and repeating these operations several times. When tungstic acid, thus purified and afterwards ignited, was reduced, a small amount of a whitish sublimate was formed, probably derived from some basic chloride of tungsten retained by the acid. In order to remove this impurity, Schneider reduced the tungstic acid, and reoxydized the metal by ignition in the air. When tungstic acid was ignited in a stream of hydrogen, he found that with the heat which a spirit-lamp can produce, the farther reduction proceeded but slowly and with difficulty, as soon as the acid was converted into the brown oxide (binoxide). Complete reduction was effected at the bright red heat of a charcoal fire; the oxide being enclosed in a glass tube, surrounded by magnesia, and lying between two iron grooves. 100 parts of tungstic acid thus yielded, in 5 experiments, from 79.254 to 79.350 metal, mean 379.316; and according to 3 experiments, in which metallic tungsten was converted into acid by ignition in the air, 100 parts of tungstic acid contain from 79.324 to 79.329, mean 79.327 metal. The atomic weight of tungsten deduced from the experiments of reduction = 93.03, and from those of oxydation = 92.09, mean 92.06.—R. F. Marchand(2) found by reduction, that tungstic acid contained from 20.693 to 20.698 per cent of oxygen, and 100 metallic tungsten absorbed by combustion to acid, from 26.07 to 26.02 of oxygen; the atomic weight of tungsten resulting as a mean from these 4 determinations is 92.05.

Tungstic Amidogen-Compounds.—Wöhler(3) has investigated the action of ammoniacal gas on bichloride of tungsten and tungstic acid.—On passing ammoniacal gas over bichloride of tungsten (WCl_2 , obtained by the combustion of metallic tungsten in chlorine gas free from air), the latter becomes so heated that it melts, and the chloride of ammonium hereby formed is volatilized; when the action is supported by heat (not stronger than is necessary to volatilize the sal-ammoniac), until no farther traces of sal-ammoniac are formed, and the product is then allowed to cool in a continuous stream of

(1) J. Pr. Chem. L, 152; Ann. Ch. Pharm. LXXVII, 263.

(2) Ann. Ch. Pharm. LXXVII, 261.

(3) Ann. Ch. Pharm. LXXIII, 190; Chem. Gaz. 1850, 161; Ann. Ch. Phys. [3] XXIX, 187; Instit. 1850, 93.

ammoniacal gas, a black, cinder-like substance is obtained. On heating this substance at the air, ammonia is given off long before ignition takes place, and the substance is converted into yellow tungstic acid. When heated in a porcelain crucible, placed between freshly-ignited charcoal-powder, to the melting heat of silver, it is reduced to pure, grey, metallic tungsten; it undergoes the same change (with disengagement of ammonia) when gently ignited in a stream of hydrogen. When fused with hydrate of potassa, tungstate of potassa is formed; by acids and aqueous alkalis it is not changed. After the removal of traces of undecomposed bichloride of tungsten or sal-ammoniac by treating it with dilute alkalis and washing, this substance was found to contain from 86·8 to 90·8 per cent of tungsten; the specimen which yielded the latter amount of tungsten, contained 8·2 per cent of nitrogen. Wöhler is of opinion that the combination of nitride of tungsten and amide of tungsten, *tungstic nitretamide* may be formed in various proportions(1); thus, $2 \text{WN} + \text{WNH}_2$ (with 86·6 per cent tungsten) is formed, besides $6 \text{NH}_4\text{Cl}$ and 1H in the decomposition of 3WCl_2 and 9NH_3 . On heating it in hydrogen, it loses 1N in the form of ammonia, thereby changing to $\text{W}_2\text{N} + \text{WNH}_2$ (with 90·4 per cent W, and 8·9 per cent N). The former compound is also decomposed in a similar manner on being heated by itself, mixtures of both combinations being formed.—These compounds cannot be produced in the moist way.

Tungstic
amidogen-
com-
pounds.

Oxide of tungstic nitretamide is obtained as a perfectly black substance by the action of dry ammoniacal gas on tungstic acid, thinly spread in a long glass tube, and heated to gentle ignition, until no more water is formed. This compound is neither decomposed by acids nor alkalis, disengages ammonia when heated by itself, burns with considerable glowing to yellow tungstic acid, when heated in the air, and with gentle glowing when heated with oxide of copper or minium. Pure oxide of tungsten and metallic tungsten exhibit the same deportment. Hypochlorite of soda dissolves this substance gradually to a tungstate, nitrogen being given off, and the odour of chloride of nitrogen becoming perceptible. When ignited in hydrogen, it is reduced to metal, with formation of ammonia and water. Heated with water in a sealed tube to 230° , it suffers no change. It contains from 87·7 to 88·5 per cent tungsten, from 3·8 to 5·5 oxygen, 7·2 nitrogen, 0·2 hydrogen; from which Wöhler deduces the formula $3 \text{WN} + \text{W}_2\text{NH}_2 + 2 \text{WO}_2$, requiring 88·0 per cent W, 7·4 N, 0·3 H, and 4·3 O.—The same or a similar compound is formed when tungstate of potassa is mixed with an excess of sal-ammoniac, the mixture covered with chloride of potassium, and fused at a strong red heat. On dissolving the fused mass in water, and

(1) These calculations are made according to Berzelius' determination of the atomic weight of tungsten (see page 206).

Tungstic
amidogen-
com.
pounds.

exhausting the undecomposed tungstate by dilute solution of potassa, a black body is left, which was formerly taken by Wöhler for a black oxide of tungsten; this substance disengages ammonia when heated by itself, or with hydrate of potassa, and is reduced to metal when exposed to a white heat in a closed vessel. On account of the hydrogen contained in this substance, Wöhler is of opinion that it is formed from another body during the treatment with water; in other respects it exhibits the same deportment as that prepared from tungstic acid in ammonia, and contains from 88 to 89 per cent W, and also in every instance from 1 to 2 per cent ammonia.

On fusing tungstate of soda with sal-ammoniac beneath a layer of common salt, and treating the mass with water and solution of potassa, a black powder is obtained, which appears under the microscope to be a mixture of an iron-coloured and of a dark copper-coloured body; the latter is considered by Wöhler to be the tungstate of tungstic oxide and soda, formerly described by him.

Brown oxide of tungsten, exposed to a gentle ignition in ammoniacal gas, also yields a product containing nitrogen and hydrogen; exposed to a strong red heat, it yields pure metal. Pure oxide of tungsten(1) has a brown-red colour, with a violet glitter; when magnified 100 times, it exhibits metallic lustre, and its colour is about that of gun-metal.

Wöhler could not prepare nitride of tungsten free from hydrogen. On igniting tungstic acid in cyanogen gas, a considerable quantity of carbonic acid was given off, and a black body of semi-metallic lustre obtained; this contained 94.5 per cent of metal, but was intimately mixed with charcoal, and yielded but little ammonia when treated with hydrated potassa.

Tungstic Acid.—Laurent(2) has published the following statements as a sequel to his former communications on tungstic acid(3). If a mixture of nitrate and carbonate of potassa be fused with an excess of tungsten (mineral), and the mass thus formed be extracted with boiling water, a brown gum-like salt is deposited from it on cooling, which, treated with hydrochloric acid yields on evaporation a salt of the composition $W_5O_{18}K\frac{1}{3}H\frac{1}{3} + 6HO$ or $W_5O_{17}K\frac{1}{3}H\frac{1}{3} + 7HO$; (fe signifies iron of the atomic weight 18.6, so that the sesqui-

(1) Wöhler had stated in this memoir, that pure oxide of tungsten is not reduced to metal by hydrogen at a strong red heat (contrary to the indication of Berzelius), that tungstic acid is reduced only to oxide by hydrogen at the melting-heat of silver, and that the oxide then undergoes no farther change. Schneider found (see page 206) that the reduction to metal is actually effected at a strong heat, and Wöhler himself (Ann. Ch. Pharm. LXXVII, 262) considered it afterwards as depending upon the difference of the temperature whether tungstic acid is reduced by hydrogen to blue or to brown oxide, or to metal.

(2) Compt. Rend. XXXI, 692.

(3) Annual Report for 1847 and 1848, I, 310; 1849, III, 184.

oxide of iron = FeO); in this salt tungstic acid and sesquioxide of iron are contained in such a state that acids do not precipitate from it the tungstic acid, nor alkalies the sesquioxide of iron; neither will sulphuretted hydrogen reduce the sesquioxide to protoxide, nor sulphide of ammonium exert any influence upon it. On heating this salt with an alkali, tungstate of the sesquioxide of iron is gradually separated, and the addition of acids then causes a copious precipitate of tungstic acid; even at red heat this salt retains some tenth of a per cent of water, corresponding to the H_2O in the second of the above formulæ.

Tungstic
acid.

This salt, the acid of which Laurent terms *ferrotungstic acid*, yields crystals of this acid when it is treated with bichloride of platinum and alcohol, and the liquor evaporated to the consistence of a syrup. With potassa and baryta two salts are obtained of the composition $\text{W}_5\text{O}_{18}\text{Fe}_2\text{K}_2\text{H}_3 + 7\text{HO}$ and $\text{W}_5\text{O}_{18}\text{Fe}_2\text{Ba}_7 + 3\text{HO}$. On igniting ferrotungstate of ammonia and then treating it with ammonia, a substance is obtained which contains iron; the greater portion, however, of the ferrotungstic acid is converted into ordinary tungstic acid.—If tungsten (the mineral) be treated with nitro-hydrochloric acid, the residue incompletely washed, and then treated with ammonia, a solution is obtained which deposits first bitungstate of ammonia; the mother-liquor, on being evaporated and mixed with some hydrochloric acid, becomes a magma of fine needles, containing tungstic acid, ammonia, the sesquioxides of iron and manganese, and water, in which, however, the presence of tungstic acid, iron and manganese is not indicated by reagents if the salt be not previously destroyed by boiling with acids or alkalies. This salt is also decomposed by being dried at 200° ; it then still dissolves with facility in water, but the solution yields on evaporation a mixture of red hexagonal tables and white needles. The composition of this salt appears to be $\text{W}_5\text{O}_{18}\text{Fe}_2\text{Mn}_2(\text{NH}_4)_3\text{H}_3 + 9\text{HO}$; by decomposing it with bichloride of platinum and evaporating to the consistence of a syrup, the *ferro-mangano-tungstic acid* contained in it may be isolated.

Molybdenum.—By estimating the amount of molybdic acid in the compound NH_4O , $2\text{MoO}_3 + \text{NH}_4\text{O}$, $3\text{MoO}_3 + 3\text{H}_2\text{O}$ (*vide* Annual Report for 1847 and 1848, I, p. 314), Beilín(1) found the atomic weight of molybdenum in four experiments = 45.86 to 46.13, mean = 45.98.—Berlin adds the following to the statements of L. Svanberg and Struve(2) on the compounds of molybdic acid and ammonia: the double salt of bi- and trimolybate of ammonia, just mentioned, which crystallizes most readily from a solution of molybdic acid in ammonia, was described by Berzelius as the neutral

(1) J Pr Chem. XLIX, 444, Ann. Ch. Pharm. LXXVI, 272.

(2) Annual Report for 1847 and 1848, I, 312.

Molybdenum.

salt. Sometimes this salt is obtained of a more or less intensely blue colour, owing to an admixture of some molybdate of oxide of molybdenum; this was regarded by Berzelius as a bimolybdate. This double salt is sometimes decomposed in contact with water at a low temperature under circumstances not thoroughly understood, so that trimolybdate of ammonia, $\text{NH}_4\text{O}, 3 \text{ MoO}_3 + x \text{ HO}$, is deposited in silky needles; this is very slightly soluble in cold water, but readily in hot water, and crystallizes in the form of a granular crust on cooling the latter solution. When hydrochloric or nitric acids are added to a solution of this double salt, the precipitate formed on each successive addition is at first redissolved on stirring, until, on farther addition of acid, the liquid suddenly solidifies into a mass of fine needles, which Berlin considers to be quadrimolybdate of ammonia, $\text{NH}_4\text{O}, 4 \text{ MoO}_3 + 2 \text{ HO}$ (dried over sulphuric acid): it does not appreciably dissolve in cold, but tolerably easily in hot water.

When the above-named double salt is powdered, then fused in a covered crucible, with twice its quantity, or more, of molybdic acid, and the excess of acid is extracted by means of ammonia, a powder of an almost metallic lustre and of a colour between brownish-yellow and violet is obtained, which is *molybdate of binoxide of molybdenum*, $\text{Mo}_3\text{O}_8 = \text{MoO}_2, 2 \text{ MoO}_3$; it is easily oxydized by nitric acid, but is not attacked by hydrochloric or sulphuric acids.—On igniting the double salt with less molybdic acid, a brown powder was found mixed with it, possessing no lustre and containing less oxygen.

Binoxide of Molybdenum.—Berzelius(1) had stated, that *binoxide of molybdenum*, MoO_2 , is formed on digesting molybdic acid with copper and hydrochloric acid; Kobell(2), however, says, that Mo_2O_3 is produced when a solution of molybdic acid in an excess of hydrochloric acid is boiled with copper. According to H. Hirzel(3), MoO_2 is formed, when molybdic acid or molybdate of lead, in the undissolved state, is brought in contact with hydrochloric acid and copper whilst the air is completely excluded; Mo_2O_3 is produced, when the molybdic acid is first completely dissolved in hydrochloric acid before it is digested with copper.

Double Sulphide of Molybdenum and Potassium.—Hirzel(4) prepared a *double salt of tersulphide of molybdenum and sulphide of potassium* (KS, MoS_3) by protected ignition of an intimate mixture of 40 carbon, 64 binoxide of molybdenum (MoO_2), 87 sulphate of potassa and 60 sulphur, extracting the mass by means of hot water and then crystallizing. For the purpose of preparing this salt, Hirzel found

(1) Lehrs. d. Chemie, 5. Aufl. II, 349.

(2) Annual Report for 1847 and 1848, I, 315.

(3) Zeitschr. f. Pharmacie, edited by the German Pharmaceutical Society, 1850, No. 1, p. 2.

(4) Ibid. p. 5.

it more advantageous to bring the solution to the point of crystallization by adding alcohol instead of by evaporating it. In other respects he confirmed the statement of Berzelius on the properties and composition of this compound.

Chromium.—Lefort(1) has made experiments on the equivalents of chromium and on the hydrates of sesquioxide of chromium.—He determined the equivalent of chromium(2) by estimating the amount of baryta in chromate of baryta (dried at 250°), which he dissolved in nitric acid and decomposed by sulphuric acid. In 14 experiments he found 100 chromate of baryta to contain from 60.01 to 60.33 baryta, mean 60.19, from which the equivalent of chromium is calculated to be = 26.6.

Sesquioxide of Chromium.—A solution of sesquioxide of chromium in potassa or soda, obtained by adding an excess of alkali to the solution of a salt of sesquioxide of chromium in any modification, gradually deposits gelatinous, green, hydrated sesquioxide of chromium, which becomes hard and black on drying. When finely powdered and dried over sulphuric acid, it is dark-green, and its composition is then expressed by $\text{Cr}_2\text{O}_3 + 6 \text{HO}$ (found 41.2 and 41.8 per cent of water, calculated 41.1 per cent); at 75° the water begins to escape. On heating a solution of sesquioxide of chromium in potassa, or on adding a salt of sesquioxide of chromium to a boiling solution of potassa, an hydrated sesquioxide of chromium is precipitated of the same external properties as the previous one, but possessing the composition $\text{Cr}_2\text{O}_3 + 5 \text{HO}$ (found 36.5 and 36.8 per cent of water; calculated 36.8); the water of which begins to escape at 80° . Lefort is of opinion that these hydrates correspond with those investigated by Fremy(3), and that the discrepant results of the latter are caused by incomplete drying (Fremy found $\text{Cr}_2\text{O}_3 + 9 \text{HO}$ and $\text{Cr}_2\text{O}_3 + 8 \text{HO}$).—When a concentrated solution of violet sulphate of sesquioxide of chromium and potassa is added to an excess of ammonia, a red precipitate is first formed and then redissolved; on the gradual disengagement of the ammonia a violet powder separates from this solution, producing with acids red solutions, which assume a violet colour when concentrated by spontaneous evaporation; it is a hydrate of the red modification of the sesquioxide of chromium, and when dried forms a greyish-violet, very-light powder of the formula $\text{Cr}_2\text{O}_3 + 9 \text{HO}$ (found 51.2 and 51.7 per cent of water, calculated 51.1); at 75° it begins to lose water, and becomes anhydrous at 120° ; on the disengagement of the water it is first transformed into the violet and then into the green

(1) J. Pharm. [3] XVIII, 27; J. Pr. Chem. LI, 261; Compt. Rend. XXX, 415 (in abstr.); Ann. Ch. Pharm. LXXV, 106.

(2) Concerning the former determinations, compare Annual Report for 1847 and 1848, I, 315.

(3) Annual Report for 1847 and 1848, I, 316.

Sesqui-
oxide of
chromium.

modification.—If the red solution, obtained by adding sulphate of sesquioxide of chromium and potassa to an excess of ammonia, be heated to a temperature not exceeding 55° , the hydrate of the violet modification of the sesquioxide of chromium is separated in the form of a greenish-grey powder, the composition of which, when it is dried over sulphuric acid, is expressed by the formula $\text{Cr}_2\text{O}_3 + 7 \text{HO}$ (found 44.2 and 44.6 per cent of water, calculated 44.9); the water commences to escape at 75° .

W. P. Blake(1) found crystallized sesquioxide of chromium in the fissures of the brickwork of a furnace which had been used during a long period for the manufacture of chromate of potassa from chrome-iron. It formed brilliant tables of at most $\frac{1}{8}$ inch in diameter, black, in thin laminæ diaphanous with green colour, and of metallic lustre; the crystals belong to the hexagonal system, $0 \text{ R} . \text{R} . - \frac{1}{2} \text{R} . \infty \text{P} 2$; he observed $0 \text{ R} : \text{R} = 121^{\circ} 55'$, $0 \text{ R} : -\frac{1}{2} \text{R} = 96^{\circ} 45'$; according to the first measurement the terminal angle of R is calculated as $85^{\circ} 22'$, the principal axis as 1.39045. The powder of the crystals is dark-green, and their hardness equal to that of sapphire.

Bichromate of Potassa.—Schabus(2) has examined the crystalline form of bichromate of potassa. It is triclinometrical; according to Naumann's mode of designation we have (the vertical line towards the face P):

$$\begin{array}{lll} A = 96^{\circ} 24' 15'' & B = 88^{\circ} 18' 0'' & C = 81^{\circ} 51' 15'' \\ a = 96^{\circ} 13' 14'' & \beta = 89^{\circ} 8' 31'' & \gamma = 81^{\circ} 59' 50'' \\ & a : b : c = 1 : 1.81467 : 1.01178 \end{array}$$

Simple forms: 0P ; $\bar{\text{P}}$, ∞ ; $\bar{\text{P}}' \infty$; $\bar{\text{P}}$, ∞ ; $\bar{\text{P}}' \infty$; $2 \bar{\text{P}}' \infty$; $\frac{1}{2} \bar{\text{P}}$, ∞ ; $4 \bar{\text{P}}$, ∞ ; P ; P ; $\infty \text{P}'$; $\infty \bar{\text{P}}$; $\infty \bar{\text{P}}' 5$; $\infty \bar{\text{P}} \infty$; cleavage highly remarkable parallel to $\infty \bar{\text{P}} \infty$, less so parallel to $\infty \bar{\text{P}} \infty$; least distinct parallel to 0P ; spec. grav. 2.689.

Bichromate of Ammonia.—Darby(3) had stated that bichromate of ammonia could not be considered as a compound of oxide of ammonium but as $\text{NH}_3, 2 \text{CrO}_3$. H. R. Richmond and J. S. Abel(4), however, found that oxide of ammonium may be assumed with certainty in this salt; on being dried over sulphuric acid *in vacuo* its composition is, according to their analyses, $\text{NH}_4\text{O}, 2 \text{CrO}_3$, and even by heating it to 100° they could not obtain a product of the composition stated by Darby.—Darby had found that a compound $\text{NH}_3, 2 \text{CrO}_3 + \text{HgCl}$ crystallizes from a solution of equal equivalents of

(1) Sill. Am. J. [2] X, 352; Chem. Gaz. 1851, 37; Ann. Ch. Pharm. LXXVIII, 121.

(2) Wien. Acad. Ber. November, 1850, 369.

(3) Annual Report for 1847 and 1848, I, 318.

(4) Chem. Soc. Qu. J. III, 199; Ann. Ch. Pharm. LXXVI, 251 (in abstr.); Laur. and Gerh. C. R. 1851, 35.

bichromate of ammonia and protochloride of mercury; Richmond and Abel obtained needle-shaped crystals from the concentrated solution, which, however, gave when analyzed varying results approaching to those of Darby; they presume that the compound may contain some uncombined protochloride of mercury. On operating so that the solution was repeatedly and but slightly concentrated, and deposited only small quantities of crystals on cooling, large, six-sided, brilliant red prisms were obtained by the first crystallizations, which, when dried over sulphuric acid *in vacuo*, were NH_4O , $2\text{CrO}_3 + \text{HgCl} + \text{HO}$; these were succeeded by more needle-shaped crystals, having the composition $3(\text{NH}_4\text{O}, 2\text{CrO}_3) + \text{HgCl}$.

Bichromate of ammonia.

Chromate of Potassa and Lime.—Thomson(1), on acting with bichromate of potassa on carbonate of magnesia, formerly obtained a compound of the formula MgO , $\text{CrO}_3 + \text{KO}$, $\text{CrO}_3 + 2\text{HO}$. A. Duncan(2) prepared the corresponding lime-compound. A boiling solution of bichromate of potassa produced with hydrate of lime a yellow solution which, on evaporation at 80° , deposited in the first place crystalline crusts of an orange-coloured salt (with 52.1 per cent of chromic acid, 24.0 lime, 17.6 potassa and 6.2 water), and then lemon-coloured, oblique prisms of the composition CaO , $\text{CrO}_3 + \text{KO}$, $\text{CrO}_3 + 2\text{HO}$, soluble in water, insoluble in cold alcohol, and fusible on application of heat. The latter salt was not formed at a boiling heat.

Nitrate of Sesquioxide of Chromium.—Nitrate of sesquioxide of chromium, according to Ordway(3), crystallizes with difficulty in warm weather; it forms purple, oblique, rhombic prisms, Cr_2O_3 , $3\text{NO}_5 + 18\text{HO}$, melting to a green liquid at a temperature of about 36° ; the solution of the crystals in cold water is purple, and becomes green when heated.

Uranium.—Patera(4) observed that the brown precipitate formed in a solution of a salt of sesquioxide of uranium by sulphide of ammonium gradually (but not commencing at the surface) assumes a blood-red colour which it retains after being filtered off, washed and dried at 100° . This red body dissolves in hydrochloric acid with disengagement of sulphuretted hydrogen and deposition of sulphur; Patera found it to contain 71 per cent of uranium and 2.75 sulphur; the amount of ammonia and water in it could not be estimated with accuracy. When this compound was boiled with caustic potassa, a red powder was obtained which Patera found to contain, when dried at 100° , 65.57 per cent of uranium, 10.60 potassium, 1.44 sulphur, and 7.50 water, and, assuming the remainder to be oxygen, he calculated

(1) Phil. Trans. for 1827, 223.

(2) Phil. Mag. [3] XXXVI, 109; J. Pr. Chem. L, 54; Ann. Ch. Pharm. LXXVI, 251; Instit. 1850, 109.

(3) Loc. cit. page 205.

(4) J. Pr. Chem. LI, 122; Ann. Ch Pharm. LXXVI, 254.

Ura-
nium.

for it the formula: $\text{KS}, 2 \text{U}_2\text{S}_3 + 21 (\text{KO}, 2 \text{U}_2\text{O}_3 + 3 \text{HO})$.—The precipitate obtained from a solution of sesquioxide of uranium by caustic potassa, when dried at 100° , he found to have the formula, $\text{KO}, 2 \text{U}_2\text{O}_3 + 3 \text{HO}$.—According to Patera, on boiling the above-mentioned red ammonium-compound with the oxides or chlorides of sodium, barium, or, strontium, or on precipitating a solution of sesquioxide of uranium with the sulphides of these metals, corresponding red compounds of sodium, barium and strontium are obtained; the barium-compound he found to contain 60.85 per cent of uranium, 1.31 sulphur, 17.54 barium, and 6.59 water. On boiling the ammonium-compound with lime or magnesia, this salt assumes a black colour.

Manganese.—According to Sobrero and Selmi(1) protochloride of manganese in aqueous solution is decomposed, with separation of binoxide of manganese, when chlorine is passed through it, if the solution contain at the same time the chlorides of potassium, sodium, calcium, or of a similar metal. This decomposition also takes place in the dark. Millon's(2) statement, that chlorine-water having been exposed to the influence of solar light may be distinguished from that which has not been thus exposed, by the former only containing hypochlorous acid and forming binoxide of manganese with protochloride of manganese, is only valid when the chlorides of the alkali-metals are absent.

Arsenic.—W. Stein(3) states that he has found a perceptible amount of arsenic(4) in the ashes of wood-charcoal when operating on at least 100 grammes of the ashes, mixed with as little water as possible and an excess of sulphuric acid; and that this is the cause of the arsenious odour disengaged on igniting charcoal; he also says he has found arsenic in the ashes of coals from the Plauen's Grund, near Dresden, of fir-wood, rye-straw, rye-chaff, *brassica oleracea*, of the root of *brassica rapa*, and of potatoes, but none in the ashes of rye and in the aqueous extract of cabbage.

Arsenites.—J. Stein(5) has examined several arsenites.—*Arsenite of ammonia* was obtained in small crystals by the action of a concentrated solution of ammonia upon arsenious acid; it can be washed with alcohol and ether, in which it is insoluble; pressed between bibulous paper it is $2 \text{NH}_4\text{O}, \text{AsO}_3$, and loses rapidly its ammonia on being exposed to the air.—*Arsenite of baryta* is formed as a white flocculent mass on adding baryta-water to a solution of arsenious

(1) Ann. Ch. Phys. [3] XXIX, 161; J. Pr. Chem. L, 305; Ann. Ch. Pharm. LXXVI, 234.

(2) Annual Report for 1849, III, 172.

(3) J. Pr. Chem. LI, 302.

(4) In an experiment made in the laboratory at Giessen, no arsenic could be detected in the ashes of charcoal.

(5) Ann. Ch. Pharm. LXXIV, 218; for former investigations on arsenites, by Pasteur and Filhol, see Annual Report for 1847 and 1848, I, 323.

acid; washed with dilute alcohol, in which it is slightly soluble, and dried over sulphuric acid, it has the composition $2 \text{BaO}, \text{AsO}_3 + 4 \text{HO}$; at 100° 2HO escape, the rest escapes on application of a higher heat, metallic arsenic subliming and arseniate of baryta being left behind.—Strontia-water is not precipitated by aqueous solution of arsenious acid, but arsenite of ammonia causes in strontia-salts a precipitation of white flakes, the amount of which increases on the addition of alcohol. *Arsenite of strontia* is pretty soluble in water, and separates, on evaporating the aqueous solution, in the form of a fine, crystalline powder. Washed with alcohol and dried over sulphuric acid, it is $\text{SrO}, \text{AsO}_3 + 4 \text{HO}$; at 100° it loses 1HO and is decomposed at a higher temperature in a similar manner to the baryta-salt.—*Arsenite of lime* is not obtained in a state of purity on precipitating arsenious acid by an excess of lime-water; most probably a mixture of $2 \text{CaO}, \text{AsO}_3$, with some $3 \text{CaO}, \text{AsO}_3$ is hereby formed. This precipitate dissolves in an excess of arsenious acid; when the latter is insufficient to effect complete solution, a salt remains behind which, when dried over sulphuric acid, has the composition $3 \text{CaO}, 2 \text{AsO}_3 + 3 \text{HO}$; it loses 1HO at 100° , and is decomposed like the preceding salt when ignited.—A mixture of solution of sulphate of magnesia and arsenite of ammonia deposits only after several days a slight precipitate; when sulphate of magnesia is mixed with chloride of ammonium until precipitation by ammonia ceases, and arsenite of ammonia and ammonia are then added, *arsenite of magnesia* is thrown down, which, after drying over sulphuric acid, is anhydrous and contains $3 \text{MgO}, \text{AsO}_3$.—Arsenite of ammonia produces a pale rose-coloured precipitate with a solution of protoxide of manganese, which rapidly becomes brown and then black on exposure to the air; washed, with the exclusion of air, and dried over sulphuric acid, this *arsenite of protoxide of manganese* is $3 \text{MnO}, 2 \text{AsO}_3 + 5 \text{HO}$; 1HO escapes at 100° , and at a higher temperature arsenious acid is given off, whilst arsenide of manganese and arseniate of protoxide of manganese are left behind. When this arsenite is evaporated with a large excess of hydrochloric acid, arsenious acid is precipitated in the form of fine crystalline flakes which cannot be resolved into single crystals, even under the microscope, and which very readily dissolve in acids and alkalis, but less so in water.

A. Reynoso(1) has drawn attention to the fact that the arsenites of several bases not themselves soluble in caustic potassa or soda, are soluble in an excess of these alkalis. The arsenite of sesquioxide of iron is very soluble in caustic potassa; the solution of arsenite of copper is blue, and is decomposed, after some time, with formation of suboxide of copper and arseniate of potassa. The solution of arsenite of protoxide of mercury undergoes almost immediate

(1) Compt. Rend. XXXI, 68; Instit. 1850, 226; J. Pr. Chem. LI, 160

Arsenites. **decomposition.** The solution of arsenite of silver is colourless, and is slowly decomposed with separation of silver in the form of a black powder; this solution is not precipitated by chloride of sodium, on the contrary, chloride of silver readily dissolves in caustic potassa when arsenite of potassa is added. When protochloride of palladium, previously mixed with arsenite of potassa, is added to a solution of arsenite of silver in potassa, a black powder is soon formed containing metallic silver and palladium; on using protochloride of platinum instead of protochloride of palladium, the reduction proceeds still more rapidly. The arsenites of cobalt, nickel and uranium dissolve in potassa & soda only in the nascent state, when arsenite of potassa with a large excess of potassa is added to a soluble salt of these metals. The solubility in alkali of the arsenites just mentioned depends, according to Réynoso, on the formation of soluble double salts of the arsenites of the metals and of the alkali. Arsenite of lead is insoluble in potassa, but soluble in soda. The arsenite of the sesquioxide of iron dissolves also in ammonia.

Arsenious Acid; Sulphides of Arsenic.—Hausmann(1) has communicated some remarks on arsenious acid, realgar (AsS_2) and orpiment (AsS_3). The hardness of newly-prepared, glassy arsenious acid is, according to him, equal to that of calcareous spar, that of the crystalline acid lies between the hardness of rock-salt and gypsum. When glassy arsenious acid passed into the opaque state, he could not on one occasion observe any crystals in the transformed substance, even on magnifying it 400 times, whilst in another case octohedrons were formed to the size of $\frac{1}{11}$ of an inch.—The native crystalline realgar on being fused and resolidified always forms again a crystalline mass, as does also the artificial, obtained by fusing together 1 As and 2 S. On the contrary, the red arsenic glass of commerce, containing sulphur and arsenic in varying proportions, is amorphous, and shows no crystalline structure whatever, even when slowly passing from the liquid to the solid state; it is specifically lighter (from 3.25 to 3.32) and harder than the crystalline realgar.—Orpiment, in its native state remarkably crystalline, becomes completely amorphous when fused, and is thereby rendered more or less intensely red, less dense (the spec. grav. of artificial vitreous orpiment was 2.76) and harder (of the hardness of calcareous spar).

Antimony. **Antimonium Crudum.**—Wittstein(2) examined (I_a) variegated sulphide of antimony (*antimonium crudum*) of Kronach, Upper Franconia (spec. grav. 5.064), (I_b) not variegated, from the same place (4.845), II. Hungarian (4.199), III. English (4.368), and

(1) Ann. Ch. Pharm. LXXIV, 188; Pogg. Ann. LXXIX, 308; Jahrb. Miner. 1850, 694; Ann. Min. [4] XVII, 167; Instit. 1850, 59.

(2) Repert. Pharm. [3] V, 67.

found the percentage of the elements and of the sulphides calculated from them as follows :

	Antimony.	Lead.	Iron.	Arsenic.	Sulphur.	SbS ₃ .	SbS ₅ .	PbS.	FeS ₂ .
Ia.	62.48	10.40	0.70	trace	26.42	81.54	4.95	12.01	1.50
Ib.	59.67	11.96	0.63	trace	27.74	65.51	19.34	13.80	1.35
II.	70.26	—	0.31	—	29.43	80.25	19.07	—	0.68
III.	71.98	—	—	—	28.02	91.98	8.02	—	—

Antimony.
Antimonium
crudum.

Wittstein assumes an amount of SbS₅ because he could not otherwise dispose of the quantity of sulphur found.—The sulphide of antimony of Kronach yields green and not red *glass of antimony* on account of its containing lead, and the *antimonium diaphoreticum* prepared from it is coloured yellow by antimoniate of lead.

Kermes.—Kosmann(1) has published investigations on kermes. He considers it the more valuable the more oxide of antimony it contains. Of the different methods for preparing kermes, he prefers that of Liebig, viz.: to boil sulphide of antimony, precipitated from its solution in caustic alkali by dilute sulphuric acid, with a solution of carbonate of soda, to filter, and to effect the separation of the kermes from the filtrate by cooling. Kermes prepared by boiling sulphide of antimony with a solution of carbonate of soda for two hours (it is not stated what quantities were operated upon) contained (when dried at 100°) 26.6 per cent oxide of antimony. By boiling the residue on the filter during the same time with the mother-liquor of the kermes and repeating this operation, products were successively obtained containing 33.2 ; 38.1, 28.4 per cent of oxide of antimony. In another preparation of kermes products were obtained, first by boiling for $\frac{1}{2}$ of an hour, with 20.4, then successively by boiling for two hours, with 35.0 and with 26.1 per cent of oxide of antimony. Kosmann rejects the method of preparing kermes by fusing together sulphide of antimony with carbonate of soda and treating the powdered mass with boiling water. From the product formed by fusing 500 grammes of sulphide of antimony and 125 grammes of anhydrous carbonate of soda he obtained, on boiling it with 2 parts of crystallized carbonate of soda and a sufficient quantity of water, a kermes of 16.6 per cent of oxide ; by boiling the residue with water during one hour, a kermes K ; and by repeatedly boiling the residues with their mother-liquor for one hour (partly with the addition of some carbonate of soda) products with 9.8, 17.6, 13.8, 17.5 per cent of oxide ; the kermes K which was mixed with a little residue, was boiled with the last mother-liquor for one hour, and a kermes thus obtained containing 21.7 per cent of oxide.

Bisulpho-terchloride of Antimony.—According to Cloez(2), when dry sulphuretted hydrogen is slowly added to pentachloride of anti-

(1) J. Pharm. [3] XVIII, 321.

(2) Ann. Ch. Phys. [3] XXX, 374 ; J. Pr. Chem. LI, 459.

Bisphospho-
terchloride of
antimony.

mony, a white crystalline compound, SbS_2Cl_3 (analogous to the compound PS_2Cl_3 , discovered by Serullas) is formed; with elevation of temperature, and disengagement of hydrochloric acid. This compound fuses at a slightly increased temperature, and is decomposed into sulphur and terchloride of antimony at higher temperatures; it does not change in dry air, attracts moisture, and is then converted into a yellow, oily liquid, containing sulphur suspended; with water it is decomposed, oxychloride of antimony and sulphur being separated; it is also decomposed by aqueous tartaric acid, a precipitate being formed of sulphide of antimony mixed with some oxide of antimony.

Zinc.—Schauëffele(1) has investigated the amount of arsenic contained in zinc of commerce, *a.* after a strange method given by Villain, viz.: to infer the weight of arsenic from the number and size of the spots obtained in Marsh's process; and *b.* after the method of Jacquelin, which consists in passing the gas developed by dissolving the zinc in sulphuric acid, into a solution of terchloride of gold, and then to estimate the arsenic in it. *Schauëffele obtained from 1000 parts of zinc, by both methods:

	<i>a.</i>	<i>b.</i>		<i>a.</i>	<i>b.</i>
French zinc . .	0.00126	0.019	Zinc of Altenberg .	0.00062	0.00522
Silesian zinc .	0.00097	0.0085	Ditto (pit Corfali) .	0.00004	0.00457

Schauëffele(2) farther observes, that a double salt, with 12.59 per cent of magnesia, and 11.60 of oxide of zinc is formed by the action of a saturated solution of sulphate of magnesia upon powdered sulphate of zinc; another, with 27.84 per cent of oxide of zinc, and 0.27 per cent of magnesia, by the action of a saturated solution of sulphate of zinc upon powdered sulphate of magnesia. From powdered sulphate of protoxide of iron and solution of sulphate of zinc, a double salt was formed, containing 13.8 per cent of oxide of zinc, and 12.1 of protoxide of iron; and by the opposite way of operating, a double salt, with 12.05 of oxide of zinc, and 14.63 of protoxide of iron.—H. Becker(3) observed, that carbonate of soda yields a slimy precipitate with solution of sulphate of zinc, and recommends for the preparation of a spongy ($\frac{2}{3}$) carbonate of zinc, to use acid solutions of zinc when precipitating cold, or else to operate at a boiling heat.

Tin. Binoxide.—Wittstein(4) thinks the cause of the different deportment of the soluble binoxide of tin (Fremy's stannic acid, H. Rose's binoxide, *a*), and of the insoluble one (Fremy's meta-

(1) J. Chim. Méd. [3] VI, 173.

(2) J. Pharm. [3] XVII, 268.

(3) Arch. Pharm. [2] LXIII, 10; Mohr draws attention to a former prescription to the same purport (Arch. Pharm. [2] LXV, 136).

(4) Repert. Pharm. [3] V, 313.

stannic acid, H. Rose's binoxide *b*) to be, that the former is amorphous, and the latter crystalline.

Lead.
Minium.

Lead. Minium.—Mulder(1) has published experiments on the minium of commerce, from which he deduces the following conclusions: The composition of minium cannot be determined by ignition, because it frequently contains a larger or smaller amount of white lead (carbonate of lead + hydrated protoxide of lead). The composition of most, if not all sorts of minium, occurring in commerce, as already stated by Houtton-Labillardière, is expressed by the formula Pb_4O_5 , more probably $Pb_2O_3 + 2 PbO$.—The discussion of an investigation by Jacquelin on minium, of which only a short abstract(2) was published during 1850, must be reserved for the next Annual Report.

With regard to the body formed by igniting nitrate of lead, which has been considered by H. Bley as a compound of oxide of lead with nitrogen, and by Stammer as a mixture of oxide of lead with minium(3), some observations have been published by the former(4), according to which the substance in question is either a mixture of different compounds of protoxide of lead and nitrogen, or more probably a mixture of a definite compound of protoxide of lead with nitrogen and ordinary protoxide of lead, not taking into consideration a small amount of minium mixed with it.

Chloride of Lead.—Schabus(5) has determined the crystalline form of chloride of lead. By spontaneous evaporation of the hydrochloric solution, distinct crystals of the rhombic system are formed, combinations of the faces $P . 2 P . 0 P . \bar{P} \infty . 4 \bar{P} \infty . \infty \bar{P} \infty$. For P the proportion of principal axis : macrodiagonal : brachydiagonal = 1 : 1.6836 : 1.0016, the terminal edges $134^\circ 24'$ and $98^\circ 45'$, the lateral edges $98^\circ 31'$. The crystals are frequently needle-shaped, in consequence of the faces of $P . 2 P . 0 P$ lying in one zone, being predominant. They present perfect cleavage in the direction of $0P$. The spec. grav. was found = 5.802.

Millon(6) had stated that only such chlorine-water as had been exposed to sunshine, and thus contains hypochlorous acid, forms binoxide of lead with chloride of lead. On examining whether the presence of the chlorides of the alkali-metals modify this behaviour, Sobrero and Selmi(7) arrived at the following results: Chlorine-water containing such chlorides, and which has been exposed to direct solar light, does not change chloride of lead to

(1) Scheik. Onderz. V, 7, Stuk, 410; J. Pr. Chem. L, 438; Repert. Pharm. [3] VI, 186; Ann. Ch. Pharm. LXXVI, 255 (in abstr.)

(2) Compt. Rend. XXXI, 626; Instit. 1850, 345.

(3) Compare Annual Report for 1849, III, 188.

(4) J. Pr. Chem. L, 380.

(5) Wien. Acad. Ber. 1850, April, 456.

(6) Annual Report for 1849, III, 172.

(7) Loc. cit. page 214.

Chloride
of lead.

binoxide, but forms with it a yellow solution. When some chloride of lead is added to a saturated solution of chloride of sodium, and chlorine is passed through it, the chloride of lead dissolves, and the solution is rendered more and more intensely yellow; a large quantity of chlorine is hereby absorbed. The solution which is formed possesses a strong odour of chlorine; it may be long preserved in close vessels, even when exposed to the solar rays; whereas it decomposes into chlorine, with separation of chloride of lead when kept in open vessels. Added drop by drop to a considerable quantity of water, it forms a precipitate of binoxide and chloride of lead. The addition of caustic alkali to the solution produces a precipitate of binoxide of lead. Carbonate of lime throws down binoxide of lead, with evolution of carbonic acid; addition of carbonate of potassa produces, frequently without evolution of carbonic acid, a light-brown precipitate, which changes to binoxide when washed and exposed to the air, and which is considered by Sobrero and Selmi as carbonate of binoxide of lead. In a similar manner they regard as phosphate of binoxide of lead the light-brown precipitate formed by phosphate of soda, and which is decomposed in a like manner on washing. With protochloride of manganese, the yellow solution yields a precipitate of binoxide of manganese and chloride of lead; it dissolves copper, iron, zinc, gold-leaf, and finely-divided platinum with rapidity, and oxydizes organic matters with violence, chloride of lead being separated in both cases. Sobrero and Selmi are of opinion that the yellow liquid contains a readily decomposable compound, $\text{PbCl}_2(1)$; they found in a solution of chloride of sodium, saturated as much as possible with chlorine and chloride of lead, for 9 equivs. NaCl , 2 Pb , and 4 Cl .—They recommend for the preparation of binoxide of lead, to saturate a solution of chloride of sodium with chloride of lead by means of chlorine, to precipitate the liquor with an alkali, and to wash the precipitate copiously with water.

J. J. Pohl(2) found the spec. grav. of an alloy of tin and lead of the composition $\text{Sn}_3\text{Pb}_4 = 9.6399$, at 15° , its melting-point $= 236^\circ$; this alloy remains for some time pasty previously to solidifying, and is very brittle between 170° and 190° . The spec. grav. of an alloy of the composition Sn_7Pb_5 , he found $= 9.2773$ at 15° , its melting-point $184^\circ.5$, its point of solidification $181^\circ.9$. This alloy is brittle between 150° and 178° .

(1) Millon (J. Pharm. [2] XXVIII, 299) had found already, on a previous occasion, that on gradually adding binoxide of lead to strongly refrigerated hydrochloric acid a yellow liquid is obtained, which produces with water binoxide of lead, forms with metals chlorides, bleaches and disengages carbonic acid with oxalic acid, and which Millon supposed to contain HCl_2 , or PbCl_2 .

(2) Wien. Acad. Ber. April, 1850, 402.

Iron.—Maumené(1) has determined the equivalent of iron by estimating the amount of sesquioxide produced from a known quantity of very pure iron-wire, on being dissolved in nitric acid, the solution precipitated with ammonia, and the precipitate thus formed washed and ignited. In 6 experiments, he found thus the equivalent of iron between 27·99 and 28·01, mean 28·00.—Rivot(2) persists in adopting Berzelius' former number 27·1 for the equivalent of iron, on the strength of two experiments of reduction of sesquioxide of iron.

Schaffner(3) stated, some time ago, that cast-iron and steel contain nitrogen; and at a later period(4) he estimated this amount at 0·5 to 1·2 per cent in cast-iron, steel, and specular iron.—Buchner, Sen.(5) suspected in the finely-powdered iron of wholesale druggists an amount of nitrogen and sulphur; on igniting a mixture of it with carbonate of potassa in a small retort, and adapting a receiver containing hydrochloric acid, but very little ammonia was obtained; water formed, however, with the residue in the retort a colourless solution, in which salts of sesquioxide of iron produced a blood-red colour. From this deportment, Buchner inferred the formation of sulphocyanide of potassium. The editors of the "*Annalen der Chem. und Pharm.*" pointed out the fallacy of this conclusion, since salts of sesquioxide of iron, added to an alkaline liquid containing sulphocyanide of potassium, yield a precipitate without the production of a blood-red colour.—R. F. Marchand(6) found the following data respecting the amount of nitrogen contained in cast-iron and steel. When finely powdered cast-iron was mixed with potassium, ignited, and the aqueous extract of it treated with sulphate of protoxide and sesquioxide of iron, and hydrochloric acid, in every instance a very copious precipitate of Prussian blue was formed. This reaction was still more apparent with steel, but was not produced in any one case with malleable iron, nor with a mixture of charcoal and pure iron. The formation of cyanogen did not succeed when an excess of potassium was used, or when the mixture was ignited in contact with the air. The iron left in this reaction always yielded again cyanogen when ignited with potassium, which led Marchand to suppose that the source of the cyanogen was not in the nitrogen of the iron, but in the atmospheric air; in fact, no cyanogen was formed on igniting the mixture of iron and potassium

(1) *Ann. Ch. Phys.* [3] XXX, 380; *Compt. Rend.* XXXI, 589; *J. Pr. Chem.* LI, 350; *Ann. Ch. Pharm.* LXXVI, 220.

(2) *Ann. Ch. Phys.* [3] XXX. 192; *Ann. Ch. Pharm.* LXXVIII, 214; *J. Pr. Chem.* LI, 341.

(3) *J. Pr. Chem.* XIX, 409.

(4) *Precht's Encyclopädie*, XV, 364.

(5) *Ann. Ch. Pharm.* LXXXIII, 215; *Repert. Pharm.* [3] IV, 228.

(6) *J. Pr. Chem.* XLIX, 351; *Chem. Gaz.* 1850, 301 (in abstr.); *Ann. Ch. Pharm.* LXXXVI, 245.

Iron. in an atmosphere of hydrogen or carbonic acid, whilst an absorption of nitrogen could be observed on igniting the mixture in an atmosphere of this gas. On estimating the amount of nitrogen in cast-iron and steel by the method of Dumas, as well as by that of Will and Varrentrapp, using as pure reagents as possible, there were in no instance more than 0.02 per cent of N found, and in most cases much less; Marchand is therefore of opinion that the presence of nitrogen in cast-iron and steel is as yet problematical. Schafhäütl's statement that the amount of nitrogen in cast-iron is concentrated in the carbonaceous residue left on its being dissolved in hydrochloric acid, he found equally devoid of proof.

Another statement of Schafhäütl(1) has been corroborated by Hull(2), viz.: that the residue left on dissolving grey cast-iron in hydrochloric acid, after being completely freed from acid, and washed with water, disengages hydrogen gas copiously, if ammonia be poured upon it. According to the experiments of Hull, the hydrogen is mechanically enclosed in the porous coal, and is disengaged from it, not only by ammonia, but also by being heated with pure water. The cause of ammonia acting even at the ordinary temperature, probably this, that it dissolves the oily carbonetted hydrogen in the coal, and thus instantly and completely wets and penetrates it.

Sesquioxide of Iron.—Sénarmont(3) found that, on heating a solution of sesquichloride of iron with carbonate of lime or carbonate of soda to at least 200° for forty-eight hours, anhydrous, red, minutely-divided sesquioxide of iron is formed, which is but little soluble in nitric acid; the same effect takes place at 160° to 180°, when heated during eight days; and, under the same circumstances, hydrated sesquioxide of iron is rendered anhydrous, if suspended in a saturated solution of chloride of sodium or calcium, or in pure water.

Salts of Iron.—Levol(4) directs attention to the fact, that on heating iron with concentrated sulphuric acid, not the sulphate of the protoxide, but that of the sesquioxide is formed; and that this latter salt is also obtained by boiling dry sulphate of protoxide of iron with concentrated sulphuric acid, with disengagement of sulphurous acid; he erroneously considers these observations as novel (comp. L. Gmelin's Handb. der Chemie, 4. Aufl. III, 230).—In order to protect the green vitriol from oxydation, Ruspini(5) recommends to keep the crystals for some time, until efflorescence sets in, at 30°, then to powder and preserve them.—Thorel(6) has made

(1) L. Gmelin's Handb. d. Chemie, 4. Aufl. III, 205.

(2) Ann. Ch. Pharm. LXXIV, 112.

(3) Loc. cit. p. 174.

(4) J. Pharm. [3] XVIII, 343.

(5) J. Chim. Méd. [3] VI, 197.

(6) J. Pharm. [3] XVIII, 337.

some communications on the purification of the green vitriol of commerce, and on the preparation of *Crocus martis aperitivus*; Jonas(1) on the preparation of *Tinctura ferri jodati*; and H. Becker(2) on the preservation of *Syrupus ferri jodati*.

Protochloride of iron.

Protochloride of Iron.—The crystalline form of protochloride of iron, $\text{FeCl} + 4\text{HO}$, is, according to Schabus(3), monoclinometric, $+P : -P :: \infty P :: 0P$. In the clinodiagonal principal section $+P : +P = 84^\circ 10'$, $-P : -P = 104^\circ 0'$, in the principal section of the base $+P : -P = 106^\circ 38'$; for P principal axis : clinodiagonal : orthodiagonal $= 1 : 1.369 : 0.837$, angle of the two first $= 69^\circ 23'$. The cleavage of the crystals is in the direction of $\infty P \infty$ and $+P$; their spec. grav. $= 1.937$; twin crystals occur, which are connected with the face $\infty P \infty$.—A solution of 3 parts of chloride of potassium and 4 parts of protochloride of iron, in as little boiling water as possible, deposits bluish-green crystals of a double salt, $\text{FeCl} + \text{KCl} + 2\text{HO}$. These are, according to Schabus(4), monoclinometric, with the prevailing faces $\infty P : \infty P \infty : (P, \infty) : 0P$; principal axis : clinodiagonal : orthodiagonal $= 1 : 0.684 : 1.358$; angle of the two former, $75^\circ 14'$; in the clinodiagonal principal section $\infty P : \infty P = 128^\circ 5'$, $(P, \infty) : (P, \infty) = 109^\circ 5'$; the spec. grav. $= 2.162$.

Nitrate of Sesquioxide of Iron.—Ordway(5) has investigated the nitrate of sesquioxide of iron. On adding metallic iron to nitric acid of spec. grav. 1.29, there is first formed a greenish solution, next a red one, and lastly a rust-coloured precipitate. When, on the appearance of the latter, the liquid is mixed with its bulk of nitric acid of ~~1.45~~ spec. grav., and cooled below 15° , or when the greenish solution is evaporated, mixed with a large excess of nitric acid, and cooled, oblique rhombic prisms of about 100° and 79° , $\text{Fe}_2\text{O}_3, 3\text{NO}_5 + 18\text{HO}$, are formed; they are deliquescent, but little soluble in nitric acid, melt at about 47° to a red liquid, and partly lose their acid even at 100° ; they do not, however, entirely lose it until nearly at red heat. 2 ounces of these crystals pounded, and mixed with 1 ounce of pounded bicarbonate of ammonia, lowered the temperature from $14^\circ.4$ to $-20^\circ.6$.—On adding this compound to freshly-precipitated hydrated sesquioxide of iron, Ordway obtained soluble basic salts, containing for 1 equiv. of nitric acid as many as 8 equivs. of sesquioxide of iron. The solutions of these salts had a deep red-colour, and were not decomposed by diluting or boiling; when, however, they contained as large an amount of sesquioxide of iron as possible, addition of chloride of sodium, sulphate of soda, and other salts, caused a separation of sesquioxide of iron. These solutions, on

(1) Arch. Pharm. [2] LXII, 307.

(3) Wien. Acad. Ber. 1850, April, 467.

(5) Loc. cit. page 205.

(2) Arch. Pharm. [2] LXIII, 10.

(4) Wien. Acad. Ber. 1850, April, 475.

Aridium, being spontaneously evaporated, yielded dark-red powders, perfectly soluble in water.

Aridium.—Ullgren(1) considers it probable that the chrome-iron of Rörös, and the iron ores of Oernstolso, contain a new metal, which he proposes to term *Aridium* (from *Ἀρης*, Mars, and *εἶδος*, quality), on account of the similarity of its oxides to those of iron.—The powdered chromium ore was digested with hydrochloric acid; the greenish-yellow solution obtained evaporated to dryness, the silica separated, again dissolved, and the solution saturated with sulphuretted hydrogen, when but a small precipitate, chiefly sulphur, was formed. In order to secure the separation of every metallic sulphide insoluble in acids, the substance was neutralized with caustic potassa, sulphide of potassium added, and afterwards as much hydrochloric acid as redissolve the black precipitate first formed, when but a small quantity of a light-yellow residue was left behind. The solution, coloured green from sesquioxide of chromium, was now treated hot with chlorate of potassa and hydrochloric acid in excess, and precipitated with potassa whilst boiling; the liquid contained chromic acid and alumina; the precipitate had a brownish-yellow colour. The latter was then fused with chlorate of potassa and (easily fusible) flux; when water extracted from the fused mass only chromic acid and some alumina. The liver-brown residue was again dissolved in hydrochloric acid, the solution precipitated with potassa, and boiled. The brown residue, after being washed, was dissolved in hydrochloric acid; the solution mixed with acetate of soda, diluted and boiled, when a light reddish-brown pulverulent precipitate was formed; whilst manganese, lime, magnesia, and a trace of zinc remained in solution. The precipitate was now dissolved in hydrochloric acid, and the solution saturated with ammonia; by which means a blackish-brown precipitate *A* was formed, part of which was dissolved in hydrochloric acid; the hydrochloric acid driven off by a carefully-adjusted quantity of sulphuric acid, and evaporated to dryness; the whitish-yellow residue interwoven with crystalline scales was dissolved in alcohol of 0·86 spec. grav., and the solution mixed with 6 times its bulk of ether, when the fluid was rendered milky, and deposited, after some time, a brown syrup. The clear liquid poured off from the latter left, after the evaporation of the ether and alcohol, a thick fluid, with brownish-black flakes enclosing inorganic impurities; the liquor separated from the latter yielded, on slow evaporation, small mammillated crystals of sulphate of oxide of aridium.—Another portion of the precipitate *A*, containing sesquioxide of iron, was ignited in a current of hydrogen, so long as water was formed; the residue

(1) From *Ofversigt af Kongl. Vetensk. Akad. Förhandl.*, 1850, 55; *J. Pr. Chem.* LII, 442; *Ann. Ch. Pharm.* LXXVI, 239; *Chem. Gaz.* 1850, 289.

then treated with nitric acid, which dissolved pure sesquioxide of iron, and left undissolved a brownish-black powder, magnetic and soluble in hydrochloric acid, without escape of gas. This powder was covered with some cyanide of potassium, strongly ignited in a crucible of graphite; it then caked, became iron-coloured, and underwent partial fusion. Dilute nitric acid extracted from this mass, with disengagement of gas, a farther amount of sesquioxide of iron, and the residue thus left was not magnetic, and dissolved in concentrated hydrochloric acid, without giving off gas. This latter is considered by Uilgren to be a lower oxide of aridium.

Uilgren gives the following statements regarding the deportment of the oxide of aridium, in order to establish his view that it contains a new metal. The oxide is dissolved by hydrochloric acid, without disengagement of gas, and leaves, on evaporation, at a gentle heat, an uncrystalline, lemon-coloured, deliquescent residue. It forms a compound with sulphuric acid, which gives a colourless solution with water. On being ignited, this compound is transformed into a reddish-brown powder, consisting of minute, microscopic crystals, which are diaphanous, with a red colour. Sulphuretted hydrogen reduces the higher oxide to the lower one; the excess of sulphuretted hydrogen being driven off, ammonia produces a greyish-white precipitate which immediately passes over into light-brown, and does not, like protoxide of iron, become first green. The solution of the lower oxide, freshly boiled, is precipitated by ferrocyanide of potassium, with a pale, whitish-green colour. This precipitate becomes darker; and after a while, bluish; when ammonia is poured upon it, it is rendered beautifully blue, and after some time, greyish-blue. The solution of the lower oxide is not precipitated by infusion of galls; with acetate of soda, it forms a pale red precipitate. The solution of the higher oxide becomes deep indigo-blue with an infusion of galls, and the addition of acetate of soda produces a brownish-violet precipitate. By ferrocyanide of potassium it is precipitated with a dark blue colour, rendered dirty bluish-green by an excess of the reagent; with ferricyanide of potassium it assumes a bluish-green hue, and gradually deposits a precipitate of the same colour. Acetate of soda produces a dark yellowish-brown precipitate; sulphocyanide of potassium, added to the solution, strikes a deep red colour, remaining even when a considerable excess of acid is present; with carbonate of soda, it yields a light brownish-yellow precipitate, and besides a yellow solution. By the sulphides of the alkalies it is precipitated with a blackish-green hue, the solution remains green for a long time, and the precipitate is readily dissolved by dilute nitric acid. The precipitate produced by the caustic alkalies closely resembles that of a solution of sesquichloride of iron; it is however more yellow, when dried more earthy, and when ignited greyish-brown. The higher oxide of aridium yields with borax before the blowpipe, in the outer

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flame, yellow beads, which become colourless on cooling; when more saturated, the beads are brownish-red, yellow when cold and opalescent; in the inner flame, light green beads are obtained; colourless, when cooled; when more saturated, they are beautifully green whilst hot, and when cold of a less pure hue. With phosphorus-salt, strongly saturated in the outer flame, the beads become dark red whilst hot, and colourless when cold; in the inner flame, when less saturated, colourless, and when more saturated, pale brown beads are obtained. With soda on charcoal, it fuses to a glass, which is absorbed by the charcoal, and yields no metal on being levigated; on platinum-wire with soda, it produces in the outer flame a glass, diaphanous with a reddish-brown colour whilst hot, and spotted brown when cold; in the inner flame, a colourless glass.

Nickel.—Schwarz(1) examined the composition of a compound containing chloride and nitrate of nickel with ammonia; its preparation is, however, not given. This compound formed azure octahedrons, became moist in the air, and smelled slightly of ammonia; dissolved in water, it formed a muddy solution, some protoxide of nickel being separated. It was decomposed when boiled, protoxide of nickel and ammonia being separated; when heated in a glass tube, it parted with its nitric acid with a violent concussion, after the water and ammonia had escaped. The analysis gave results corresponding to the formula $(3 \text{ NH}_3 + \text{NiCl}) + 6 (2 \text{ NH}_3, \text{NiO}, \text{NO}_5 + \text{HO}) + 10 \text{ HO}$.

Mercury.—According to Bärensprung(2), some of the mercury in the *Unguentum mercuriale cinereum* (grey ointment) is ointment in form of the suboxide, and the more of it, the older the ointment is; the fat of the ointment being removed by means of ether, the protoxide may be extracted from the metallic residue by means of water mixed with a few drops of sulphuric acid(3).—Bolley(4) observed that *cinnabar* assumes almost instantaneously a black colour when a solution of nitrate of silver, to which ammonia in excess has been added, is poured upon it; it exhibits this deportment even when mixed with other substances and used as colouring matter, and may be readily recognized by it. In this decomposition sulphide of silver, and compounds of basic nitrate of protoxide of mercury, with simple amide of mercury, are formed(5).—Riegel(6) convinced himself that protochloride of mercury does not evaporate at an ordinary temperature, either by itself or from concentrated solutions; he found,

(1) Wien. Acad. Ber. March, 1850, 272; J. Pr. Chem. LI, 319.

(2) J. Pr. Chem. L, 21; Repert. Pharm. [3] VI, 152.

(3) In such a water an amount of metal was found, but it was not ascertained whether this was mercury.

(4) Ann. Ch. Pharm. LXXV, 239.

(5) Orpiment and sulphide of tin, freshly precipitated, exhibit the same deportment towards nitrate of silver without ammonia.

(6) Arch. Pharm. [2] LXI, 294.

moreover, that mercury is not soluble in water(1).—According to H. Hirzel(2), the double sulphate of potassa and protoxide of mercury, $\text{KO}, \text{SO}_3 + 3 (\text{HgO}, \text{SO}_3) + 2 \text{HO}$, is obtained in large, colourless, monoclinometric crystals, by dissolving 1 equiv. of dry sulphate of protoxide of mercury in sulphuric acid, heat being applied, digesting the solution with 1 equiv. of sulphate of potassa, until complete solution is effected; then gradually adding boiling water, until a permanent cloudiness just begins to appear; and lastly, allowing it to cool slowly. By a corresponding process, double sulphate of ammonia and protoxide of mercury was obtained in large monoclinometric crystals, rendered black in the light. This salt, according to his analysis (which did not, however, yield concordant results), he suspects contains an admixture of *ammoniacal turpethum*.—Some experiments by Joule(3), on the preparation of various amalgams, have only been published in short abstracts. He prepared the amalgams of iron and of copper by electrolysis of solutions of iron and copper, mercury forming the end of the negative pole. The amalgam of copper, when completely saturated with copper, possessed the composition CuHg . When solutions of metals in mercury are pressed out under very high pressure, amalgams of a definite composition are left behind, according to Joule; thus he states that he has obtained PtHg_2 , AgHg_2 , CuHg , FeHg , Zn_2Hg , Pb_2Hg , Sn_7Hg .

Silver.—Du Ménil(4) found that the method of Wittstein(5), viz.: to reduce chloride of silver by heating with charcoal powder, is worthy of recommendation. (?)

Gold. Teroxide of Gold.—Fremy(6) has communicated researches on gold. He confirmed the formula of protochloride of gold, AuCl . Compounds of protoxide of gold and the alkalies cannot be prepared, because the former is decomposed into gold and teroxide of gold, when brought into contact with the latter. Compounds of teroxide of gold and the alkalies can, however, be obtained with facility. Fremy prepared teroxide of gold by boiling terchloride of gold with an excess of potassa, until it assumed a pale yellow colour, and then precipitating the teroxide of gold with sulphuric acid; he purified it by dissolving it in concentrated nitric acid, precipitating with water, and washing. The teroxide of gold thus prepared, he found to be insoluble in oxygen acids (with the exception of concentrated nitric

(1) Compare Wiggers' and L. Gmelin's experiments (L. Gmelin's Handb. d. Chemie, 4, Aufl. III, 470).

(2) Zeitschr. f. Pharmacie, 1850, 6, 17.

(3) Chem. Gaz. 1850, 339; Instit. 1850, 327.

(4) Arch. Pharm. [2] LXII, 161.

(5) Annual Report for 1849, III, 195.

(6) Compt. Rend. XXXI, 893; Instit. 1851, 1; J. Pharm. [3] XIX, 84; J. Pr. Chem. LII, 159; more in detail, Ann. Ch. Phys. [3] XXXI, 478; Ann. Ch. Pharm. LXXIX, 40.

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of gold.

acid), and in hydrofluoric acid, easily soluble in hydrochloric and hydrobromic acids. It combines rapidly with potassa and soda, and the solutions yield, on evaporation *in vacuo*, aurate of potassa and of soda in a crystalline form. Aurate of potassa crystallizes in small, silky, pale yellow tufts, $\text{KO}_2, \text{AuO}_3 + 6 \text{HO}$; it readily dissolves in water, forming a yellow liquor of alkaline reaction; it is decomposed below a red heat into metallic gold, potassa, together with peroxide of potassium, and oxygen. With aurate of potassa, the insoluble compounds of teroxide of gold and bases can be prepared by double decomposition; these compounds are partly soluble in an excess of the solution used for their preparation; thus, for instance, aurate of lime is readily soluble in an excess of chloride of calcium. On adding sulphite of potassa to aurate of potassa, a yellow salt immediately separates, which can be obtained in long silky needles, and which has been termed by Fremy *aurosulphite of potassa* (*aurosulfite de potasse*); its composition can be expressed by $\text{AuO}_3, 3 \text{SO}_2 + 5 (\text{KO}, \text{SO}_2) + 5 \text{HO}$, or by $\text{KO}, \text{AuO}_3 + 4 (\text{KO}, 2 \text{SO}_2) + 5 \text{HO}$. Fremy supposes, however, that the potassa in this salt is united with an acid, consisting of gold, sulphur, and oxygen, similar to the *sulphazotic acid*(1) discovered by him, which consists of nitrogen, sulphur, and oxygen. *Aurosulphite of potassa* is decomposed, after a few months, even when dried *in vacuo* and kept in sealed tubes, into a blackish mass, which consists chiefly of metallic gold and sulphate of potassa. With pure water (with ~~rapidly~~ when boiling) it is decomposed, sulphurous acid is given off, and a clear liquor is formed, from which afterwards metallic gold is precipitated.

Sulphide of Gold.—Levol(2) has communicated some observations concerning the decomposition of terchloride of gold by sulphuretted hydrogen, which are at variance with those hitherto known. From a boiling solution of terchloride of gold sulphuretted hydrogen precipitated a brownish-yellow body, which was not AuS , but pure gold; from a cold solution of terchloride of gold, sulphuretted hydrogen precipitated a black powder, which lost its water completely only at 140° , and was not AuS_3 , but AuS_2 .—Levol determined the equivalent of gold by estimating the quantity of sulphuric acid formed by a known weight of gold, after being converted into terchloride of gold, and then acting on sulphurous acid. In two experiments, he obtained uniformly the number 196.3.

Platinum.—Fremy(3) prepared binocide of platinum by boiling bichloride of platinum with a large excess of caustic soda, and decomposing the compound of binocide of platinum and soda with

(1) Ann. Ch. Phys. [3] XV, 208; Berzelius' Jahresber. XXVI, 94.

(2) Ann. Ch. Phys. [3] XXX, 355; J. Pr. Chem. LI, 446.

(3) In the more detailed memoir quoted page 227.

acetic acid. Binoxide of platinum is precipitated with a nankeen-yellow colour as hydrate; it dissolves in potassa and in soda; crystallized compounds of binoxide of platinum with bases could not, however, be obtained.

Platinum-bases.

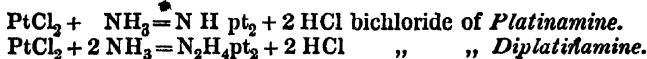
Platinum-Bases.—Gerhardt(1) has communicated investigations on the so-called platinum-bases; he views them, in accordance with Laurent(2), as ammonia, in which various quantities of hydrogen are replaced by platinum; whereby, according to the views of these chemists(3), the platinum can enter into combination with different atomic weights, as *platinosum* $Pt=98.7$, and as *platinicum* $pt=49.4$; so that protoxide of platinum is expressed by PtO , and binoxide of platinum by ptO .

By the name of Reiset's salts, two series of peculiar salts of platinum are known; the chlorides in both series may be considered as compounds of protochloride of platinum with 2 (the chloride of Reiset's first series), or with 1 equiv. of ammonia (the chloride of Reiset's second series). Gerhardt views both salts as compounds of hydrochloric acid with ammonia, in which hydrogen is replaced by platinosum:



He terms the basis in the second series of Reiset (ammonia, in which 1 H is replaced by 1 Pt) *platosamine* $=NH_3Pt$; the basis of the first series (a basis formed by the union of 2 equivs. of ammonia to one, of which 1 equiv. H is then replaced by 1 Pt) *diplatossamine* $=N_2H_5Pt$ (4).

According to his view, we may, by a corresponding action of bichloride of platinum $PtCl_2=pt_2Cl_2$ upon ammonia, conceive the formation of chlorides of bases which differ from the preceding ones by being formed in consequence of the replacement of 2 H in ammonia by 2 pt ($=Pt$). The two compounds of bichloride of platinum with ammonia, corresponding to the compounds of the protochloride alluded to above, would be:



(1) Laur. and Gerh. C. R. 1850, 273; Compt. Rend. XXXI, 241 (in abstr.); Ann. Ch. Pharm. LXXVI, 307; J. Pr. Chem. LI, 351.

(2) Laur. and Gerh. C. R. 1850, 204.

(3) Compare Laurent's views, Annual Report for 1849, III, 148.

(4) Wurtz (Ann. Ch. Phys. [3] XXX, 488) entertains the same view as Gerhardt respecting the composition of the basis in the salts of Reiset's first and second series; he assigns, however, different names to these bases, viz. to N_2H_5Pt , *Platinamine* and to NH_3Pt , *Platinia*. Analogous in composition to the basis N_2H_5Pt , he regards the basis *cupramine* N_2H_5Cu , which he assumes in the so-called copper sal-ammoniac.—On analogous platinum-bases, which are derived from methylamine and ethylamine, instead of from ammonia, see the articles upon the former.

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Gerhardt has prepared the compound described as bichloride of platinamine, and has investigated the salts of platinamine generally. —Bichloride of diplatinamine is the compound of Gros, $\text{PtCl}_2, 2 \text{NH}_3$, hitherto considered as a protochloride, $\text{PtN}_2\text{H}_5\text{Cl} + \text{HCl}$, because only 1 part of its chlorine is precipitated from its cold aqueous solution by solution of silver, and because it forms, with an excess of nitric acid, a nitrate $\text{PtN}_2\text{H}_5\text{Cl}, \text{HO} + \text{NO}_5 = \text{PtClO}, 2 \text{NH}_3 + \text{NO}_5$. Gerhardt considers that the basis of Gros's salts contains no chlorine; from the solution of the sulphate of Gros's basis also, he says, the sulphuric acid is not precipitated by baryta-salts; it is more rational to consider the chloride of Gros's basis, mentioned as bichloride of diplatinamine, and the other salts of the basis, as double salts, containing, besides hydrochloric acid, a second acid. According to Gerhardt, the double salts described by Raewsky(1) are of this kind also, in other proportions, in which Raewsky assumed a basis of a complicated composition, containing platinum and chlorine (see p. 231).

Gerhardt's particular results on the substances, termed by him compounds of platinamine and diplatinamine, are as follows. (In order to render Gerhardt's mode of viewing them more intelligible we have retained in the formula, as an exception, the symbol pt_2 , equivalent with Pt).

Platinamine separates in the form of small brilliant crystals, when a boiling solution of nitrate of platinamine is mixed with ammonia in excess. The crystals are $\text{NHpt}_2 + 4 \text{HO}$; they lose nothing in weight at 130° , are scarcely soluble in boiling water, but readily soluble in dilute acids (even acetic acid). Boiling solution of potassa disengages no ammonia either from platinamine or from its salts.—*Bichloride of platinamine* is obtained by the action of chlorine on chloride of platosamine (the chloride of the second series of Reiset's salts, $\text{NH}_2\text{Pt} + \text{HCl}$), suspended in boiling water; the chloride of platosamine is thereby converted into a heavy lemon-coloured powder, consisting of octahedral crystals, $\text{NHpt}_2 + 2 \text{HCl}$ ($= \text{PtCl}_2 + \text{NH}_3$); insoluble in cold, and but little soluble in boiling water, and in water acidulated with hydrochloric acid. When boiled with ammonia, this compound is dissolved, and on evaporation bichloride of diplatinamine is obtained, $\text{N}_2\text{H}_4\text{pt}_2 + 2 \text{HCl} = \text{PtCl}_2 + 2 \text{NH}_3$, the chloride of Gros's series. Concentrated nitric or sulphuric acids do not act upon bichloride of platinamine, even on boiling; neither does bichloride of platinum. Caustic potassa disengages no ammonia from it, even on boiling; it dissolves it, however, to a gold-coloured liquor, from which acids precipitate a yellowish substance, insoluble in boiling acetic acid, and of a different deportment from that of platinamine. —*Nitrate of platinamine* is obtained by boiling the bichloride, sus-

pended in a large quantity of water, with nitrate of silver, until no more chloride of silver is formed; from the liquid, filtered whilst boiling, the nitrate separates on cooling in the form of a crystalline, granular, yellowish powder (microscopic rhombic, or six-sided tables). It is $\text{NHpt}_2, \text{HO}, \text{NO}_5 + 4 \text{HO}$, little soluble in cold, but more easily in hot water. The yellowish solution reddens litmus, and yields with potassa or ammonia a precipitate of platinamine; with carbonate of soda, a yellowish-white crystalline, with phosphate of soda, a flocculent white precipitate, soluble in an excess of the solution of the phosphate. It is not precipitated by hydrochloric acid whilst cold, but easily, when gently heated, bichloride of platinamine being formed.—*Binitrate of platinamine*, $\text{NHpt}_2 + 2 [\text{HO}, \text{NO}_5]$, is obtained by mixing the solution of the preceding salt with nitric acid, and evaporating; it forms a crystalline mass, and, after being washed and dried, a yellowish powder.—*Oxalate of platinamine* is prepared by decomposing the nitrate by means of oxalate of ammonia; it forms a pale yellow crystalline precipitate, which is obtained in yellow tables when recrystallized from hot water. It is (dried at 120°) $\text{NHpt}_2, \text{HO}, \text{C}_2\text{O}_3 + 3 \text{HO}$, and detonates, when heated, like oxalate of silver.—*Bisulphate of platinamine* separates in crystalline tablets, on evaporating the solution of platinamine in dilute sulphuric acid. When washed with alcohol, it forms a yellow powder of an acid taste, pretty soluble in water, $\text{NHpt}_2 + 2 [\text{HO}, \text{SO}_3]$.

The salts of *diplatinamine* are formed by the action of nitric acid or chlorine on the salts of diplatamine (salts of Reiset's first series). The base contained in them is $\text{N}_2\text{H}_4\text{pt}_2$ (see p. 229). It contains the elements of platinamine and ammonia, and its salts may therefore also be viewed as double compounds of platinamine and ammonia. Its salts disengage ammonia on being heated with a concentrated solution of potassa, and the bichloride of diplatamine is formed on boiling bichloride of platinamine with ammonia (p. 230). Diplatinamine cannot be isolated; it forms salts with 1, $1\frac{1}{2}$ and 2 equivs. of acid, frequently containing two different acids. The salts with 2 equivs. of acid are those of Gros's series (see p. 230), which are represented by the general formula $\text{N}_2\text{H}_4\text{pt}_2 + \text{HCl} + \text{Ac}, \text{HO}$, (when Ac, HO signifies the hydrate of an acid). The salts with $1\frac{1}{2}$ equivs. of acid are those of Raewsky(1), represented by the general formula $2 \text{N}_2\text{H}_4\text{pt}_2 + \text{HCl} + 2 (\text{Ac}, \text{HO})$.—*Bichloride of diptatinamine*, $\text{N}_2\text{H}_4\text{pt}_2 + 2 \text{HCl}$, is the compound already prepared by Gros by the action of hydrochloric acid or chlorides on the nitrate of Gros's series. In order to obtain it, Gerhardt prefers the method given by Reiset, viz.: to act with chlorine upon a solution of chloride of diplatamine (the chloride of

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Reiset's first series). A third method for its formation has just been mentioned (p. 231). Identical with it is, finally, the salt which Raewsky considers as $\text{Pt}_2\text{N}_4\text{H}_{12}\text{Cl}_2\text{O}_3, \text{Cl}_2$.—If this salt be boiled for a few minutes with an excess of solution of nitrate of silver, and filtered whilst boiling, a yellow crystalline mass deposits from the filtrate on cooling, which is purified by recrystallization from boiling water; it then forms small, brilliant, hard, rhombic tables, and is, when dried at 120° , *sesquichloro-nitrate of diplatinamine*, $= 2 \text{N}_2\text{H}_4\text{pt}_2 + \text{HCl} + 2 (\text{NO}_3, \text{HO}) + 2 \text{HO}$. Gerhardt found the salt prepared by Raewsky himself, and designated by him as $\text{Pt}_2\text{N}_4\text{H}_{12}\text{ClO}_3, 2 \text{NO}_3$, to be identical with it. The solution of this salt forms, with hydrochloric acid, a white precipitate of bichloride; with oxalate of ammonia, a yellowish-white, crystalline precipitate; dried at 120° , $2 \text{N}_2\text{H}_4\text{pt}_2 + \text{HCl} + 2 (\text{C}_2\text{O}_3, \text{HO}) + 2 \text{HO}$; identical with the salt which Raewsky views as $\text{Pt}_2\text{N}_4\text{H}_{12}\text{ClO}_3, 2 \text{C}_2\text{O}_3$. The carbonate and phosphate examined by Raewsky, Gerhardt considers as $2 \text{N}_2\text{H}_4\text{pt}_2 + \text{HCl} + 2 (\text{CO}_2, \text{HO}) + 2 \text{HO}$, and $2 \text{N}_2\text{H}_4\text{pt}_2 + \text{HCl} + \text{PO}_5, 3 \text{HO}$.

The green compound of Magnûs is viewed by Gerhardt as chloroplatinite(1) of diplatosamine, $\text{N}_2\text{H}_5\text{Pt}, \text{PtHCl}_3$; the yellow compound, isomeric with it (the chloride of Reiset's second series), as chloride of platosamine, $\text{NH}_2\text{Pt}, \text{HCl}$. Just as the latter forms a salt of platinamine when acted upon by chlorine, the former yields, under the same influence, a salt of diplatinamine, whilst moreover the chloroplatinous acid is converted into chloroplatinic acid. When the green compound is suspended in boiling water, and a current of chlorine is passed through it, it is converted into a red, brilliant, crystalline powder, the chloroplatinate of diplatosamine $\text{N}_2\text{H}_5\text{Pt}, \text{PtHCl}_3$, already prepared by Reiset. The liquor assumes a red colour, and on continuing the current of chlorine, the red compound first formed is partly dissolved, partly converted into a yellowish-white, crystalline precipitate. If the action of the chlorine be interrupted, as soon as the red body has entirely disappeared, the liquor then evaporated and mixed with alcohol, chloride of chloroplatinate of diplatinamine is deposited in yellow brilliant tables or prisms, which (dried at 120°) are $\text{N}_2\text{H}_4\text{pt}_2 + \text{HCl} + \text{PtHCl}_3 + \text{HO}$.

Gerhardt and Laurent described formerly(2) a resinous substance formed by the action of ammonia on chloroplatinate of ammonia (ammonio-chloride of platinum), having the composition PtClN_2H_5 ; this substance might accordingly be *chloride of platinamine*.—By adding hydrochloric acid, bichloride of diplatinamine could, however, not be

(1) The term *chloroplatinous acid* is assigned by Gerhardt to the compound of protochloride of platinum and hydrochloric acid; that of *chloroplatinic acid* to the compound of bichloride of platinum and hydrochloric acid.

(2) Annual Report for 1849, III, 196.

obtained from it, and, generally, it could not be decided whether diplatinamine was contained in the above substance. Platinum
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A salt of diplatinamine, free from chlorine, could not be prepared either by treating the bichloride with sulphuric acid, or by treating the sesquichloro-nitrate with nitrate of silver; its formation succeeded, however, by treating nitrate of diplatamine (nitrate of Reiset's first series) with hot concentrated nitric acid. In contact with this acid the crystals of that salt are converted into a blue powder, which by continued boiling is again decolorized; when recrystallized from boiling water, *sesquinitrate of diplatinamine* is obtained in the form of a white crystalline powder, little soluble in cold water, and which, dried at 130° , is $2 \text{ N}_2\text{H}_4\text{pt}_2 + 3 (\text{NO}_5, \text{HO}) + 2 \text{ HO}$. When boiled with liquid ammonia this powder dissolves, and on cooling the solution *protonitrate of diplatinamine* separates as a white amorphous powder, which, when dried at 130° , is $\text{N}_2\text{H}_4\text{pt}_2 + \text{NO}_5, \text{HO} + 2 \text{ HO}$; it detonates with violence when heated in a tube, and becomes blue on being moistened with sulphuric acid; when the aqueous solution of this salt is boiled with hydrochloric acid, bichloride of diplatinamine separates. From the solution of the sesquinitrate, oxalate of ammonia precipitates *sesquinitro-oxalate of diplatinamine* in white flakes, which, dried at 130° , is $2 \text{ N}_2\text{H}_4\text{pt}_2 + \text{NO}_5, \text{HO} + 2 (\text{C}_2\text{O}_3, \text{HO}) + 2 \text{ HO}$; it likewise explodes when heated in a tube.

ORGANIC CHEMISTRY.

General
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Views on
the
radicals.

General Matters. Views on the Radicals.—Kolbe(1) has communicated some investigations on the chemical constitution and nature of the organic radicals. He assumes the existence of groups of intimately combined atoms in the organic radicals themselves; he views, for instance, acetyl as being composed of 2 equivs. of carbon and the adjunct methyl, and writes its rational formula thus $(C_2H_3)^-C_2$, in which C_2 forms exclusively the point of attack for the chemical action of oxygen, chlorine, &c. He assumes radicals of an analogous composition in the acids homologous to acetic acid, and expresses, for instance, the rational formula of formic acid by $HO \cdot H^-C_2, O_3$, that of propionic (metacetic) acid by $HO \cdot (C_4H_5)^-C_2, O_3$, &c. Aldehyde he regards as $HO \cdot (C_2H_3)^-C_2, O$; chloral as $HO \cdot (C_2Cl_3)^-C_2, O$. He considers it probable that the hydrogen in the complex of atoms, which, coupled with C_2 , form the organic radicals, may be replaced entirely or partially by chlorine, hyponitric acid, &c. Benzoic acid he regards as bearing the same relation to the hydrated oxide of phenyl (phenylic acid, phenole) as acetic acid does to the hydrate of oxide of methyl (wood-spirit), viz.: as containing a radical in which phenyl forms the adjunct of C_2 , and which he terms benzoyl = $(C_{12}H_5)^-C_2$. The hydrocarbons C_2H_3 , C_4H_5 , $C_{12}H_5$, and others, can combine, not only with C_2 , but also with metals, sulphur, &c., in order to form organic radicals; cacodyl, he says, contains $(C_2H_3)_2$ coupled with As, and the compounds of the alcohol-radicals with metals(2), discovered by Frankland, he considers possess a similar constitution. Kolbe views benzole as the hydride of phenyl $(C_{12}H_5)H$, and gives similar formulæ for its homologues. In the compounds derived from naphthalin, he assumes a radical $C_{20}H_7$, which he calls naphthyl; naphthalin itself, according to this view, is hydride of naphthyl $(C_{20}H_7)H$. We must content ourselves with the quotation of the above results, and cannot enter farther into the extensive questions raised by Kolbe on the rational constitution of different groups of compounds and of single bodies, with regard to which we have to refer to the

(1) Ann. Ch. Pharm. LXXV, 211; LXXVI, 1; Chem. Soc. Qu. J. III, 369; IV, 80.

(2) Compare Annual Report for 1849, III, 283.

original paper. We only add the more general result, that Kolbe attempts to reconcile the adoption of changeable (by substitution) radicals with the electro-chemical theory by supposing that the same element may possess different electro-chemical properties in different combinations; for instance, hydrogen in acetyl on the one side, and in water or in hydrochloric acid on the other; to support this view, he points out that an element, even in its isolated state—for instance, phosphorus in the ordinary and in the red modification—may possess a very different electro-chemical character.

General
matters.
Views on
the
radicals.

Views on the so-called Alcohol-Radicals.—Many contradictory views have been started on the constitution of those compounds which possess the composition of the so-called alcohol-radicals, and which have been prepared in their isolated state—methyl(1), ethyl(2), butyl(3), &c. The formulæ given by Frankland and Kolbe to these compounds (C_2H_3 to methyl, C_4H_5 to ethyl, C_8H_9 to butyl, &c., in their isolated state) express a condensation of 1 equiv. of the gas or vapour of the compound to 2 volumes. Several chemists have asserted, and have attempted to support their view by various arguments, that these formulæ are to be doubled in order to obtain a condensation to 4 vols., as is usual in organic compounds, whilst other chemists have disputed this view.

Gerhardt(4) expressed the opinion that the formula of the so-called methyl must be doubled, and be written C_4H_6 , and that this gas itself should be considered as a homologue of marsh-gas; he repeats this assertion for the so-called isolated radicals in general(5), and observes that these substances by no means show the deportment as regards their affinities, which could be expected if they were to be considered as real radicals, viz.: comparable to metals.

A. W. Hofmann(6) also considers the doubled formulæ (expressing condensation to 4 vols.) as the more probable ones; he points out that no case has as yet been observed in which the so-called alcohol-radicals combine directly with another element, or otherwise reproduce a methyl-, ethyl-, or amyl-compound; he also draws attention to the unusual condensation which these hydrocarbons would possess according to the formulæ of Frankland and Kolbe; he shows that by adopting the double formulæ the boiling-points of those alcohol-radicals, for which this property could be determined, coincide with the regularity so frequently met with, viz.: that in analogous compounds an increase of C_2H_2 corresponds to an

(1) Annual Report for 1847 and 1848, II, 16; Annual Report for 1849, III, 277.

(2) Annual Report for 1849, III, 283.

(3) Annual Report for 1849, III, 288.

(4) Laur. and Gerh. C. R. 1849, 19.

(5) Laur. and Gerh. C. R. 1850, 11.

(6) Chem. Soc. Qu. J. III, 121; Ann. Ch. Pharm. LXXVII, 161; J. Pharm. [3] XVII, 470 (in abstr.); Laur. and Gerh. C. R. 1850, 225.

Views on
the so-
called
alcohol-
radicals.

elevation of 23° in the boiling-point. He proves farther, that the adoption of the doubled formulæ is not opposed to the chemical deportment of these compounds. Hofmann certainly acknowledges that the mode in which these so-called radicals are formed, supports the formulæ of Frankland and Kolbe; for just as iodide of hydrogen (hydriodic acid) and zinc yield iodide of zinc and hydrogen, so, according to Frankland and Kolbe, the iodide of an alcohol-radical and zinc yield iodide of zinc and the alcohol-radical, but the analogy was not complete, inasmuch as in the action of zinc on a hydrogen-acid no compound of zinc and hydrogen was formed corresponding to zinc-methyl. But although Hofmann supports the doubling of the formulæ of these compounds, he by no means agrees with Gerhardt in viewing them as homologues of marsh-gas, but considers them rather as only isomeric with the homologues of that body(1).

Frankland(2) retains the view that the simple formulæ (expressing condensation to 2 volumes) of the compounds in question, are the correct ones, and attempts to show that these bodies possess exactly the chemical deportment and character of hydrogen, being only less electro-positive than this element. He adopts, however, the doubled formula for the gas formed from zinc-ethyl and water(3) or by the splitting of ethyl into C_4H_4 and C_4H_6 , which gas he formerly viewed as methyl C_2H_3 , and considers it to be hydride of ethyl, C_4H_5 , H. He besides thinks it probable that the so-called methyl-gas(4) formed by the decomposition of cyanide of ethyl with potassium is also hydride of ethyl, and only isomeric with the true radical methyl, this latter being obtained by the electrolysis of acetic acid(5) and by the decomposition of iodide of methyl with zinc(6).—In order to prove still more directly that this methyl possesses the same composition as the hydride of ethyl, without however being identical with it, Frankland(7) investigated the action of chlorine on the compounds distinguished by him as hydride of ethyl and as methyl. He had found, already in conjunction with Kolbe(8) that 1 volume of the hydride of ethyl is transformed by 1 volume of chlorine-gas into 1 volume HCl, and 1 volume of a gas C_4H_5Cl , which is only isomeric with chloride of ethyl, but not identical, and the rational formula of which he now writes as $C_4H_4 + H$. With methyl-gas, prepared by

(1) Gerhardt acknowledges the possibility of the latter view (Laur. and Gerh. C. R. 1850, 233).

(2) Ann. Ch. Pharm. LXXIV, 41; Chem. Soc. Qu. J. III, 30.

(3) Annual Report for 1849, III, 288.

(4) Annual Report for 1847 and 1848, II, 16.

(5) Annual Report for 1849, III, 228.

(6) Annual Report for 1849, III, 287.

(7) Ann. Ch. Pharm. LXXVII, 221; Chem. Soc. Qu. J. III, 322.

(8) Annual Report for 1847 and 1848, II, 16.

electrolysis of acetic acid, Frankland obtained the following results. By the action of 1 vol. of chlorine-gas upon 1 vol. of methyl-gas, 1 vol. HCl and 1 vol. of a gas C_4H_5Cl is also formed, as in the case of the hydride of ethyl; but Frankland is of opinion that 2 vols. of chlorine may combine with 1 vol. of methyl forming 1 vol. HCl and 1 vol. of a gas C_2H_2Cl , this latter then yielding, with the remaining volume of methyl, a mixture of the composition C_4H_5Cl . In order to decide this, he acted upon 1 vol. of methyl with 2 vols. of chlorine, and found actually that hereby 2 vols. of HCl and 1 vol. of a gas C_2H_2Cl (corresponding to a condensation to 2 vols.) are formed. By the action of 2 vols. of chlorine upon 1 vol. of hydride of ethyl (prepared by treating iodide of ethyl with zinc in the presence of water) probably 2 vols. of HCl are formed, according to him, along with a liquid of the composition of the oil of olefant-gas ($C_4H_4Cl_2$), the identity or isomerism of which, with this body, Frankland leaves undecided. He thinks himself justified in concluding from these experiments that two series of hydrocarbons of the empirical formula $C_nH_n + H_1$ exist, the members of which are isomeric, and that the gaseous hydrocarbon, formed by the electrolysis of acetic acid, possesses the formula C_2H_3 and is condensed to 2 vols., whilst the gas, formed by the action of potassium upon (moist) cyanide of ethyl, and of zinc upon iodide of ethyl, in the presence of water, possesses the formula C_4H_6 , and is condensed to 4 vols. He farther attempts to refute Hofmann's arguments in favour of the doubling of the formulæ; he disputes the position that these radicals could justly be expected to be capable of combining directly with the metalloids, or of being brought back into their former combinations after having been isolated; he admits that the condensation assumed by him differs from that of the other carbonetted hydrogens, but it agrees with that of the simple radical, hydrogen. The laws of the boiling-points are as yet too little investigated to be capable of being used with any degree of certainty for establishing formulæ, and comparisons of boiling-points might be produced, which would be in favour of the simple formulæ, expressing a condensation to 2 vols.; disengagement of hydride of zinc, by passing hydrochloric acid over heated zinc, could not be expected, because the former would instantly be decomposed by the excess of hydrochloric acid.—Kolbe(1) also attempted to show that neither the want of energy of the so-called alcohol-radicals to combine with other elements, nor the relations of the boiling-points require a doubling of their formulæ.

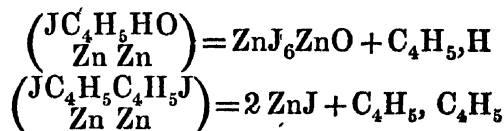
Wurtz(2), however, has also expressed himself in favour of the doubled formulæ, contesting the arguments brought forward by Frankland in his paper to support his own view.

(1) Loc. cit. page 234.

(2) J. Pharm. [3] XVIII, 230; XIX, 308.

Views on
the so-
called
alcohol-
radicals.

Laurent(1), in a paper on the radicals, has pointed out that 2 molecules of the so-called alcohol-radicals in their nascent state might combine to a single molecule, which would elucidate the cause of the doubling of Frankland and Kolbe's formulæ. Hofmann(2) viewing the reaction in a similar manner, has attempted to unite the molecules of different radicals into one compound. He heated iodide of amyl and zinc-ethyl for some time in a sealed glass tube, expecting to form iodide of zinc and ethyl-amyl (C_4H_5 , $C_{10}H_{11}$); the substance distilling over on the tube being opened, consisted, however, solely of iodide of amyl and zinc-ethyl.—Brodie(3)—in accordance with his views that less complex constituents of the same kind may have mutual affinities(4)—is also of opinion that two molecules of an alcohol-radical combine together in their nascent state; he considers as analogous processes the decomposition of iodide of ethyl by zinc in the presence of water (whereby hydride of ethyl is formed), and in the absence of water:



In order to put this view to the test, he tried to decompose zinc-ethyl and iodide of ethyl into iodide of zinc and ethyl (C_4H_5 , C_4H_5), and found the experiment to succeed when ether (in which zinc-ethyl is soluble) is added for the purpose of assisting the reaction. He put iodide of ethyl with a little zinc, and twice its bulk of ether into a glass tube, which he then sealed; on heating it to 100° for several hours the zinc disappeared with formation of zinc-ethyl; and only a trace of gas; the tube being now heated to 170° , a large quantity of white crystals separated; on opening the tube under water much gas escaped, containing ethyl, olefiant-gas and hydride of ethyl, and the residue contained not a trace of zinc-ethyl; (zinc does not act upon ether by itself at this temperature.) Brodie likewise considers it possible to produce compounds of different alcohol-radicals, C_2H_3 , C_4H_5 ; C_4H_5 , $C_{10}H_{11}$ &c.

Cyanogen and Cyanogen-Compounds. Formation of Cyanogen.—Riegel(5) confirmed the fact already known, that hydrocyanic acid is formed in the preparation of *Spiritus nitri dulcis*, but

(1) Laur. and Gerh. C. R. 1850, 241.

(2) Ann. Ch. Pharm. LXXVII, 180.

(3) Chem. Soc. Qu. J. III, 405; Ann. Ch. Pharm. LXXVIII, 168.

(4) Compare page 170.

(5) Jahrb. Pr. Pharm. XX, 143. According to recent communications of Wöhler,

only when the distillation proceeds rapidly. He also observed that soda of commerce contained cyanide of sodium.

Hydrocyanic acid.

Hydrocyanic Acid.—Wöhler has, some time since(1), published a method for the preparation of anhydrous prussic acid by distilling 2 parts of cyanide of potassium (obtained by fusing 8 parts of dry yellow prussiate of potassa, 3 parts of charred cream of tartar, and 1 part of charcoal) dissolved in 6 parts of water with 1 part of sulphuric acid previously diluted with 1 part of water, and desiccating the prussic acid disengaged by means of cyanide of potassium and chloride of calcium contained in a U-shaped tube. Some of the objections to this method, mentioned by L. Gmelin(2) (namely, the clogging up of the U tube in consequence of the above salts dissolving in the water distilling over) may, according to a recent communication of Wöhler(3) be readily avoided by placing the neck of the retort upwards at an angle of about 45° , and by putting between the retort and the U tube a vessel containing some chloride of calcium and cyanide of potassium. The chloride-of-calcium-tube and the intervening vessel are put, from the commencement, into water of 30° ; the hydrocyanic acid gas is condensed in a high and narrow receiver, which, on account of the crystallizing of the acid, is lowered from time to time and surrounded with a mixture of common salt and ice. According to Wöhler, anhydrous prussic acid is most cheaply prepared directly from yellow prussiate of potassa, by distilling 10 parts of this salt with 7 parts of sulphuric acid and 14 parts of water, in the same manner as stated above (when cyanide of potassium is used) the mixture boils uniformly, and without "bumping," over an open charcoal fire.

Cyanuric Acid.—Limpricht(4), in a preliminary notice, has communicated the most important results of an investigation on the compounds derived from cyanuric acid and ether. He starts from the view that the cyanurate of oxide of ethyl, $3C_4H_5O, C_6N_3O_3$, discovered by Wurtz(5)—with the existence of which Wöhler's(6) opinion of cyanuric acid being a bibasic acid is at variance—contains neither cyanuric acid nor oxide of ethyl, inasmuch as it is not decomposed by the action of the alkalis like the other ethers into acid and alcohol, but into carbonic acid and ethylamine. Limpricht observed that this decomposition is preceded by the formation of a body of the formula

the formation of cyanogen from sugar-charcoal and the nitrogen of the atmosphere, is established beyond doubt; the main conditions are, that a temperature is applied as high as is required for making potassium, and that the nitrogen is previously exposed to a red heat.

(1) Berzelius' Lehrb. I, 816; and Handwörterb. der Chemie, II, 406.

(2) Handb. d. Chemie, 4. Aufl. IV, 315.

(3) Ann. Ch. Pharm. LXXIII, 218.

(4) Ann. Ch. Pharm. LXXIV, 208; Laur. and Gerh. C. R. 1850, 307.

(5) Annual Report for 1847 and 1848, II, 19.

(6) Annual Report for 1847 and 1848, I, 375.

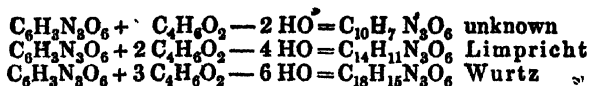
Cyanuric
acid.

$C_{15}H_{18}N_3O_3$. By boiling the cyanurate of oxide of ethyl with baryta-water (potassa produces however the same effect), 3 equivs. of carbonic acid unite with the baryta whilst 3 equivs. of water are taken up, and after the base is removed, a substance similar to turpentin, and possessing the above composition, is left behind. This body distils at 170° , partly without being changed, partly with decomposition into ethylamine and the less volatile body $C_{11}H_{11}N_2O_3$ ($C_{15}H_{18}N_3O_3 = C_4H_7N + C_{11}H_{11}N_2O_3$); this decomposition takes place still more rapidly at 200° .

This latter solid substance exhibits neither an acid nor alkaline reaction; it fuses at 106° , sublimes at about 250° , and decomposes when boiled with potassa into carbonic acid and ethylamine ($C_{11}H_{11}N_2O_3 + 3HO = 3CO_2 + 2C_4H_7N$).

Another body belonging to this group, of the formula $C_{14}H_{11}N_3O_6$, has been discovered by Limpricht on preparing Wurtz' cyanuric ether, when towards the end of the operation, by increased heat, it distils over from the mixture of sulphovinate and cyanurate of potassa, apparently combined with methylamine; it is not crystallizable in this combination and remains therefore in the mother-liquor of the cyanuric ether. By boiling this compound with baryta-water it is decomposed, methylamine being disengaged, and the new body, after the baryta is removed by means of sulphuric acid, crystallizes from the liquid in fine six-sided prisms pointed by 3 faces. It is pretty soluble in hot water, alcohol, and ether, and crystallizes from the latter solutions in obtuse rhombohedrons. The aqueous solution is then sealed. Heated to 173° the substance fuses, either in ammonia, potassa, or chloric acid gas, and readily soluble in water, and crystallizes from these solutions unchanged. It now heat decomposed; it does not increase in weight, and deposits net. opening. The aqueous solution mixed with nitrate of silver, precipitated by salts of silver, and crystals $= C_{14}H_{10}N_3O_5, AgO$; it is also precipitated by salts of mercury. The crystals are also precipitated by the oxides of lead and copper, and of suboxide of potassa. The lead-compound when heated with sulphovinate, yields the cyanuric ether of Wurtz.

Gerhardt (1) points out that the body $C_{15}H_{18}N_3O_3$, discovered by Limpricht, might be neutral carbonate of ethylamine minus water, the formula of ethylamine-urea $= C_{10}H_{12}N_2O_2$; Gerhardt thinks that by Limpricht's formula $C_6H_5NO_2$ is more probable for the second body discovered by Limpricht ($C_{11}H_{11}N_2O_3$); the latter would then be derived from the former simply by the elimination of ethylamine: $C_{10}H_{12}N_2O_2 = C_4H_7N + C_6H_5NO_2$. The third body obtained by Limpricht might be cyanuric acid, standing between the cyanuric ether of Wurtz and the true (as yet unknown) cyanuro-vinic acid; we should have then:



Iodide of cyanogen.

corresponding to the various phosphovinic acids of Lassaigue and Pelouze and of Vögel(1). The fact that neither alcohol nor cyanuric acid can be regenerated from cyanuric ether by means of the alkalies is, according to Gerhardt, no proof against the tribasic nature of cyanuric acid, inasmuch, as then cyanide of ethyl likewise could not be considered as a true ethyl-compound, yielding as it does with the alkalies, propionic acid and ammonia.

Iodide of Cyanogen.—C. Herzog(2) has described the properties of iodide of cyanogen; there is, however, nothing new to be gleaned from his statements. Iodide of cyanogen crystallizes from its solution in ether or absolute alcohol in small four-sided tables, and from that in alcohol of 80 per cent in long feathery needles. Sulphuric and hydrochloric acids decompose it only at a high temperature, nitric acid not at all; solutions of metallic salts (copper, iron, zinc, silver, gold and platinum) effect also no decomposition of iodide of cyanogen in its aqueous solution. An alcoholic solution of ammonia dissolves copiously iodide of cyanogen and then deposits crystals of a compound of ammonia and iodide of cyanogen, which disappear gradually when exposed to the air.—Iodine containing cyanogen, when treated with metallic iron and water, yields a liquid compound, besides iodide of iron also a compound of iron; carbonate of potassa, however, precipitates the whole amount of cyanogen along with the iron; iodide of potassa prepared in this way is therefore free from cyanogen even when the iodine employed contained iodide of cyanogen. An analysis of iodide of cyanogen made by Herzog led to the formula already established = C_2I .

Chloride of Cyanogen.—Gaseous chloride of cyanogen is best prepared, according to Wöhler(3), in the following manner: a saturated solution of cyanide of mercury mixed with an excess of this salt in a finely powdered state, is saturated with chlorine, and the remaining space of the vessel, only partially filled with the solution, is filled with chlorine gas. The vessel is then closed and left standing in the dark, until after repeated shaking all chlorine is combined, or all the cyanide of mercury dissolved. In order to remove any free chlorine the solution is agitated with some mercury. The liquid is then heated in a flask connected with a chloride-of-calcium-tube and a conducting-tube, until gentle boiling ensues through the disengagement of chloride of cyanogen. To condense the chloride of cyanogen, it is conducted into a tube surrounded by snow and common salt.

(1) Annual Report for 1847 and 1848, I, 21.

(2) Arch. Pharm. [2] LXI, 129.

(3) Ann. Ch. Pharm. LXXIII, 219.

Bichloride
of tita-
nium—
Chloride of
cyanogen.

Bichloride of Titanium—Chloride of Cyanogen.—Wöhler has also made a more close investigation of the compound of chloride of cyanogen and bichloride of titanium, formerly (1) observed by him (2). This compound is formed instantaneously, and with considerable evolution of heat, when gaseous chloride of cyanogen is passed into bichloride of titanium. The latter is soon transformed into a voluminous, yellow, crystalline mass, the complete saturation of which with chloride of cyanogen is, towards the end, assisted by shaking and gentle heating. The compound is lemon-coloured, and begins to volatilize considerably below 100° , subliming to clear, lemon-coloured crystals, whose form appears to be a rhombic pyramid; it fumes in moist air, and is shortly afterwards rendered milk-white, with disengagement of the odour of chloride of cyanogen. Water dissolves it, forming a perfectly clear solution, with disengagement of heat and chloride of cyanogen. In warm bichloride of titanium it is soluble, without undergoing any change, and crystallizes from the solution on cooling. It absorbs ammonia with considerable development of heat, forming a deep orange-coloured compound, which is also rendered white in moist air, and is decomposed by water with partial separation of titanous acid. The composition of this compound is $\text{CyCl} + 2\text{TiCl}_2$ (calculated 75.56 per cent of chloride of titanium, found 75.89).—No similar compound could be produced with bichloride of tin.

Bichloride of Titanium—Hydrocyanic Acid.—Wöhler (3) has farther discovered a compound of bichloride of titanium with hydrocyanic acid. On adding ~~an aqueous solution of~~ hydrocyanic acid to the bichloride, the combination immediately takes place, with disengagement of heat and boiling (the substances have therefore to be cooled to 0° previous to their being mixed, or gaseous hydrocyanic acid is to be passed into the bichloride), and with formation of a pulverulent yellow mass; the excess of hydrocyanic acid is then distilled off, and the compound itself sublimed by cautious heating. This compound is very volatile, and sublimes below 100° , forming clear, brilliant, lemon-coloured crystals (rhombic pyramids and their combinations), which unite to a coherent mass when rapidly sublimed. In the air, it feebly fumes, emits a strong odour of hydrocyanic acid, rapidly becomes white, and deliquesces soon, forming a clear, thick solution. With water, it forms a clear solution, with disengagement of heat (when little water is used, hydrocyanic acid gas is given off); by subliming it in chlorine gas, it suffers no change; on passing its vapour through a red-hot glass tube, it coats the latter with copper-coloured nitride of

(1) Annual Report for 1849, III, 180.

(2) Ann. Ch. Pharm. LXXIII, 219; Pogg. Ann. LXXIX, 327; J. Pr. Chem. L, 233; Ann. Ch. Phys. [3] XXIX, 182; Inst. 1850, 62.

(3) Ann. Ch. Pharm. LXXIII, 226; Ann. Ch. Phys. [3] XXIX, 184.

titanium, mixed with carbon. Its composition is $\text{HCy} + \text{TiCl}_2$ (calculated 77.86 per cent of bichloride of titanium, found 78.67 per cent).

In connection with these investigations, L. Klein(1) has prepared compounds of hydrocyanic acid with the chlorides of tin, antimony and iron, and of chloride of cyanogen with the chlorides of antimony and iron.

Bichloride
of tin—
Hydro-
cyanic
acid.

Bichloride of Tin—Hydrocyanic Acid.—Bichloride of tin combines with anhydrous hydrocyanic acid, without appreciable heating, forming a solid crystalline body, which is obtained in fine crystals, when hydrocyanic acid gas is passed into bichloride of tin, presenting a large surface in a tube. The crystals are colourless, powerfully reflecting the light, and apparently isomorphous with the corresponding compound of titanium. In a current of H_2 air, they volatilize as rapidly as anhydrous prussic acid, and are then rendered white and opaque; they are decomposed in moist air, as well as by water, and unite with ammoniacal gas, forming a white, sublimable body.—According to Klein likewise, bichloride of tin does not appear to enter into combination with chloride of cyanogen.

Pentachloride of Antimony—Hydrocyanic Acid.—When the vapour of anhydrous hydrocyanic acid is brought in contact with pentachloride of antimony, heated to 30° , distinct clear prisms are formed of the compound, which volatilizes between 70° and 100° , with partial decomposition, even in a current of carbonic acid. It deliquesces, does not fume in the air, is decomposed by water, with separation of antimonic acid, and combines with ammonia, forming a brownish-red, pulverulent mass. The analysis yielded the formula $\text{SbCl}_5 + 3 \text{HCy}$.

Pentachloride of Antimony—Chloride of Cyanogen.—On passing gaseous chloride of cyanogen into pentachloride of antimony until saturation, a crystalline white mass is formed, which is decomposed in a great measure on heating, and also by water. With ammonia, it combines to a yellow pulverulent body.

Sesquichloride of Iron—Hydrocyanic Acid.—Sublimed sesquichloride of iron combines with anhydrous hydrocyanic acid, with a hissing noise, to a brownish-red liquid which soon solidifies into a crystalline mass. This compound deliquesces in moist air, hydrocyanic acid being given off; it fuses at 100° , and combines with ammonia, forming a greenish-black powder which dissolves in water, with separation of Prussian blue, and which also contains protochloride of iron. The analysis yielded the formula $\text{Fe}_2\text{Cl}_3 + 2 \text{HCy}$.

Sesquichloride of Iron—Chloride of Cyanogen.—Sublimed sesquichloride of iron fuses in gaseous chloride of cyanogen to a black

(1) Ann. Ch. Pharm. LXXIV, 85; Chem. Gaz. 1850, 313; Laur. and Gerh. C. R. 1850, 316.

Subcyanide of copper.

mass, yielding on heating chloride of cyanogen, partly in solid crystals.

Subcyanide of Copper.—Subcyanide of copper(1) forms, according to Dauber(2), small brilliant crystals $\infty P . \infty P \infty . 0 P$ of the monoclinometric system; $\infty P : \infty P$ in the clinodiagonal principal section $= 68^{\circ} 32'$, $0 P : \infty P = 70^{\circ} 16'$, $0 P : \infty P \infty = 53^{\circ} 10'$, orthodiagonal : clinodiagonal $= 0.5453 : 1$; remarkable cleavage parallel to $0 P$.

Ammonio-ferrocyanide of Nickel.—A solution of freshly precipitated ferrocyanide of nickel in an excess of ammonia deposits, according to A. Reynoso(3), in a short time, a violet crystalline compound, which can be dried without decomposition only in a current of dry ammoniacal gas. Its formula is $FeCy_3, 2 Ni + 5 NH_3 + 4 HO$. Once dried, this compound loses water and ammonia only between 100° and 150° ; when boiled with water, it splits in the same manner, leaving pure ferrocyanide of nickel behind. Dilute acids effect the same decomposition. The same compound is also obtained on adding ferrocyanide of potassium to a solution of a salt of protoxide of nickel, containing a large excess of ammonia.—Another compound of ferrocyanide of nickel with ammonia, for which Reynoso gives the formula $FeCy_3, 2 Ni + 2 NH_3, HO$, is obtained in the form of a greenish-white precipitate, on mixing nitrate of protoxide of nickel and ammonia with ferrocyanide of potassium.

Ammonio-ferricyanide of Nickel.—Ferricyanide of potassium produces, with the nitrate of protoxide of nickel and ammonia, a fine yellow precipitate, soluble in an excess of ammonia, and of the composition $Fe_2Cy_6, 3 Ni + 2 NH_3 + HO$.

Ferricyanide of Potassium.—The crystalline form of ferricyanide of potassium is, according to Schabus(4), rhombic. For the type P he gives the ratio of the brachydiagonal : macrodiagonal : principal axis $= 1.2418 : 1.6076 : 1$; forms occurring $\infty P, \infty \bar{P} \infty, P, \bar{P} 2$, and $\frac{3}{2} \bar{P} \frac{1}{2}$; in the macrodiagonal principal section, according to him, $\infty P : \infty P = 75^{\circ} 26'$, $P : P = 111^{\circ} 16'$, $\bar{P} 2 : \bar{P} 2 = 104^{\circ} 50'$, $\frac{3}{2} \bar{P} \frac{3}{2} : \frac{3}{2} \bar{P} \frac{3}{2} = 119^{\circ} 0'$. In consequence of a combination of $\bar{P} 2$.

(1) According to a later communication of Wöhler (Ann. Ch. Pharm. LXXVIII, 370), these exceedingly brilliant and iridescent crystals are anhydrous; they are prepared by decomposing cupro-cyanide of lead mixed with water, by means of so much sulphuretted hydrogen that the cupro-hydrocyanic acid first formed is not decomposed, and by allowing the solution, filtered from the sulphide of lead, to evaporate spontaneously, when hydrocyanic acid and crystallizing subcyanide of copper are formed; the crystals became opaque and white on heating, without changing their form and weight.

• (2) Ann. Ch. Pharm. LXXIV, 206.

(3) Ann. Ch. Phys. [3] XXX, 252; Compt. Rend. XXX, 409; Instit. 1850, 114; J. Pharm. [3] XVIII, 37; J. Pr. Chem. LI, 119.

(4) Wien. Acad. Ber. May, 1850, 582.

on the one side of the brachydiagonal principal section, and of $\frac{1}{2} \tilde{P} \frac{1}{2}$ on the other side, with ∞P and $\infty \tilde{P} \infty$, crystals are formed, according to Schabus, of a monoclinometric appearance(1). The spec. grav. is 1.8004. (Concerning the colour, comp. p. 113).

Nitro-
prussides.

Nitroprussides.—Barreswil(2) ascribes the formation of hydronitroprussic acid (comp. Annual Report for 1849, III, p. 200) to the action of hyponitric acid (formed from nitric oxide by access of air), inasmuch as, according to his experiments, ferrocyanide of potassium is not decomposed by nitric oxide.

J. Kyd(3) has subjected to analysis the nitroprusside of sodium, and obtained numbers which appear decidedly in favour of the more simple formula $\text{Fe}_2\text{Cy}_5\text{NO}, 2\text{Na} + 4\text{HO}$, which Playfair also considered as not improbable. (Comp. Annual Report for 1849, III, pp. 202, 205).

Sesquicyanide of Platinum and Potassium.—The salt obtained by Knop, in the form of copper-red needles, by treating Gmelin's platino-cyanide of potassium with chlorine, is, according to its discoverer, $2\text{KC}_y, \text{Pt}_2\text{Cy}_3 + 5\text{HO}$; according to L. Gmelin $= \text{KC}_y, \text{PtCy}_2 + 3\text{HO}$ (4). Gerhardt(5) convinced himself that Knop's formula is the true one, excepting 1 equiv. of water. Gerhardt finds the formula $2\text{KC}_y, \text{Pt}_2\text{Cy}_3 + 6\text{HO}$; he considers, however, the salt to be a compound of platino-cyanide of potassium with protocyanide of platinum $= 2\text{KC}_y, \text{PtCy}_2 + \text{PtCy} + 6\text{HO}$, in order to avoid the assumption of the existence of a sesquicyanide of platinum.—The compound obtained by Knop and Schnedermann by the action of aqua-regia on the above salt would then have an analogous composition, only containing bichloride of platinum in lieu of protoxide of platinum $= 2\text{KC}_y, \text{PtCy}_2 + \text{PtCl}_2 + 4\text{HO}$.

Platino-cyanide of Barium.—The crystalline form of platino-cyanide of barium ($\text{Pt}_5\text{Ba}_6\text{Cy}_{11} + 22\text{HO}$, according to Quadrat; comp. Annual Report for 1847 and 1848, I, p. 370, and Annual Report for 1849, III, p. 205), is, according to Schabus(6), monoclinometric; orthodiagonal : clinodiagonal : principal axis $= 2.0861 : 1.8145 : 1$; angle

(1) H. Kopp observed crystals of ferricyanide of potassium, perfectly developed, of an undoubtedly monoclinometric habitus; the combination $\infty P. \infty P. \infty. + P. - P$; orthodiagonal : clinodiagonal : principal axis $= 0.7457 : 1 : 0.5985$; angle of the two latter $72^\circ 27'$; in the clinodiagonal principal section $\infty P : \infty P = 76^\circ 4'$, $+ P : + P = 105^\circ 4'$, $- P : - P = 119^\circ 28'$. The form considered here as $+ P$ would be identical with Schabus' $\tilde{P} 2, - P$ with $\frac{1}{2} \tilde{P} \frac{1}{2}$; crystals of apparently right rhombic habitus are accordingly formed by twin formations; the twin face parallel $\infty P \infty$. Schabus does not state expressly whether he observed crystals developed at both ends.

(2) J. Pharm. [3] XVII, 441.

(3) Ann. Ch. Pharm. LXXIV, 340; Phil. Mag. [3] XXXVII, 289; J. Pr. Chem. LI, 315.

(4) Gmelin's Handb. d. Chemie, 4. Aufl. IV, 440.

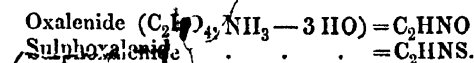
(5) Laur. and Gerh. C. R. 1850, 145.

(6) Wien. Acad. Ber. May, 1850, 569.

Platino-
cyanide of
barium.

of the two latter, $75^{\circ} 53'$; ordinary combination, $\infty P . \infty P \infty . (\infty P \infty) . (P \infty)$; in the clinodiagonal principal section $\infty P : \infty P = 99^{\circ} 42'$, $(P \infty) : (P \infty) = 130^{\circ} 8'$; sometimes two faces of $(P \infty)$ lying on one side of the clinodiagonal principal section, are particularly developed, thus supplanting the two corresponding faces on the other side. The crystals appear siskin-coloured when viewed in the direction of the principal section, and sulphur-coloured at right angles to it (as has been described already by Haidinger); their spec. grav., according to Schabus, is 3.054.

Cyanogen and Hydrosulphuric Acid.—Laurent(1) has again investigated the composition of the compound of cyanogen and sulphuretted hydrogen, discovered by Gay-Lussac [Anderthalb-hydrothioncyan, Gmelin; hydride of flavcan, Berzelius(2)]. He prepared it by introducing cyanogen gas and sulphuretted hydrogen (the latter being in great excess) into a large bottle, the sides of which were moistened with water. The yellow needles formed were purified by careful recrystallization from ether. The analysis yielded 26.0 per cent of carbon, 2.3 per cent of hydrogen, 38.2 per cent of sulphur, and (as loss) 33.5 per cent of nitrogen. Laurent's formula for it, $C_4H_2S_2N_2$ or C_2HSN , requires 27.9 per cent of carbon, 2.3 per cent of hydrogen, 37.2 per cent of sulphur, and 32.6 per cent of nitrogen. These yellow crystals split, by the action of acids and alkalis, in the presence of water, into oxalic acid and ammonia, analogous to the sulphoxamide, $C_2NH_2S_2$ (zweifachhydrothioncyan, Gmelin; hydride of rubean, Berzelius). Laurent considers them, therefore, as a kind of amide of oxalic acid, *sulphoxaleni* (*oxalénide sulfurée*); the sulphur-compound corresponding to the, as yet unknown, *oxalénide* (oxalate of ammonia minus 3 equivs. of water):



Sulphocyanide of Potassium.—In order to prepare sulphocyanide of potassium after the method of Liebig(3), Henneberg(4) fuses first 17 parts of carbonate of potassa with 32 parts of sulphur to hepar, and then adds 46 parts of roasted yellow prussiate of potassa, until the mass fuses quietly, and every reaction of ferrocyanide of potassium has disappeared. The iron crucible is then well closed, and exposed to a gentle red heat, which is at last increased for a short time in order to destroy the hyposulphite of potassa. The fused

(1) Laur. and Gerh. C. R. 1850, 373; Compt. Rend. XXX, 618 (in abstr.); Instit. 1850, 162.

(2) L. Gmelin's Handb. d. Chemie, 4. Aufl. IV, 495; compare Völckel's investigations, ibid.

(3) Ann. Ch. Pharm. L, 345; LI, 288; L. Gmelin's Handb. d. Chemie, 4. Aufl. IV, 462.

(4) Loc. cit. page 248.

mass is repeatedly boiled with water, the solution poured off from the sulphide of iron neutralized by dilute sulphuric acid, if required, and then evaporated to crystallization. The salt obtained is recrystallized from alcohol.

Sulpho-
cyanide of
lead.

Sulphocyanide of Lead.—The crystalline form of sulphocyanide of lead (PbC_2NS_2) is, according to Schabus(1), monoclinometric; principal axis : clinodiagonal : orthodiagonal = 1 : 1.162 : 0.923; angle of the two latter, $65^\circ 2'$; occurring forms, $+P, -3P, 0P, \infty P 2, +3P \infty$; in the clinodiagonal principal section $\infty P 2 : \infty P 2 = 120^\circ 38', 0P : \infty P 2 = 111^\circ 31', 0P : +P = 116^\circ 55', 0P : -3P = 119^\circ 3', 0P : +3P \infty = 87^\circ 45'$. The spec. grav., according to Schabus, is 3.82.

Sulphocyanide of Copper.—J. Hull(2) has discovered a compound of subsulphocyanide of copper with sulphocyanide of copper (Kupferferrodanür-Rhodanid). This is obtained pure on dissolving black sulphocyanide of copper in an alcoholic solution of sulphocyanide of potassium with application of heat, and gently evaporating the solution, when it separates with the colour of orpiment; it is filtered off, and at first washed with alcohol, then with water, in order to remove the sulphate of potassa produced. It forms an orpiment-coloured, amorphous powder, unchanged by water, insoluble in sulphocyanide of potassium, and it is decomposed by caustic potassa, with formation of sulphocyanide of potassium. It is not changed by hydrochloric acid, not even when chlorate of potassa is added. Concentrated nitric acid, however, acts upon it with great violence, producing sulphuric acid. The analysis led to the formula $\text{Cu}_2\text{C}_2\text{NS}_2 + \text{CuC}_2\text{NS}_2$. The same compound appears to be formed on gently heating dry sulphocyanide of copper on platinum-foil over the spirit-lamp, when the mass rapidly becomes brownish-yellow, with disengagement of bisulphide of carbon, cyanogen, and other products.

Protosulphocyanide of copper is best prepared, according to Hull, when, in the first place, a slight excess of sulphuric acid is added to a moderately concentrated, cold solution of sulphocyanide of potassium, previously rendered free from air by boiling, and then immediately afterwards a saturated solution of sulphate of copper, also free from air. The compound immediately separates in the form of a black, crystalline precipitate, which can easily be washed with cold water, free from air.—A compound of sub- or protosulphocyanide of copper with sulphocyanide of potassium, could not be obtained by Hull.

Sulphocyanide of Silver and Potassium.—On placing a warm saturated solution of sulphocyanide of silver in sulphocyanide of potassium over sulphuric acid, colourless, brilliant crystals are formed, which

Sulpho-
cyanide of
silver and
potassium.

undergo no change in the air, when freed from the mother-liquor. They belong to the rhombic system, and form rhombic octahedrons, with a brachydiagonal prism and the terminal faces of the macrodiagonal. They are decomposed by water into sulphocyanide of potassium and crystalline sulphocyanide of silver. They fuse at 140° , and are decomposed at a higher temperature. Analysis led to the formula $KC_2NS_2 + AgC_2NS_2$.—Freshly precipitated cyanide and chloride of silver readily dissolve in sulphocyanide of potassium; no definite compound, however, could be obtained from this solution.

Mellon-Compounds. Mellonide of Potassium.—W. Hennberg(1) has made an important addition to our knowledge of the mellon-compounds. On the preparation of mellonide of potassium on the large scale, he gives the following particulars:

When preparing this salt by fusing crude mellon with sulphocyanide of potassium, the utmost care in the operation is requisite to insure success. Sulphocyanide of potassium, purified by crystallization from alcohol, is converted into sulphocyanogen by passing chlorine through its aqueous solution whilst warm, and this, after being carefully washed by boiling it with water, and then completely dried, is calcined at a temperature not higher, at first, than is necessary to drive off the sulphur. This is best done at the commencement in a porcelain basin, and then in a covered porcelain crucible, because when using a retort, the sulphur on distilling off is apt to flow back, whereby the neck cokes. An excessive heat is also to be avoided to prevent the mellon from caking. Mellon thus prepared is light yellow with a slight mixture of grey; a grey or reddish-brown product is to be regarded as failure, inasmuch as the preparations made from it do not turn out satisfactorily. The mellon is triturated and, previously to its being used, strongly ignited.

From 3 to 5 parts (15 to 20 grammes) of pure sulphocyanide of potassium are now fused in a retort over the spirit-lamp until all the moisture is driven off, and then 1 part (5 grammes) of mellon is added; when more mellon is used the mass is too difficult to fuse and swells too much. When the disengagement of sulphurous vapours has ceased and the contents of the retort fuse uniformly, the heat, at first moderate, is increased, taking care to exclude the air as much as possible, and the operation is interrupted only when delicate crystalline needles appear on cooling, at those places of the retort over which the fused mass has been made to flow in thin layers. A measure for the temperature is given by the incipient

(1) Ann. Ch. Pharm. LXXIII, 228; Chem. Gaz. 1850, 268; Laur. and Gerh. C. R. 1850, 98.

disengagement of cyanogen, the appearance of which indicates decomposition of the mellon by too high a temperature.

The neck of the retort being cleaned from the brown products of distillation, the mass is treated with hot water, filtered and evaporated in the water-bath after the addition of a few drops of acetic acid. Sometimes a slimy body, no longer soluble in water, is hereby separated. The crystals of mellonide of potassium thus obtained, are rendered colourless by boiling the very dilute solution with acetic acid and animal charcoal and then neutralizing the filtrate with a few drops of potassa. The solutions are then properly concentrated, and the crystalline mass obtained is washed with alcohol, but only at last, because it impedes the decolorization.

Mellon-
com-
pounds.
Mellonide
of potas-
sium.

The fusion of ferrocyanide of potassium with half its weight of sulphur, or better, according to Henneberg, 10 parts of the former to $5\frac{1}{2}$ or 6 parts of the latter, gives a purer product, but is more uncertain than the method just described. The addition of $\frac{1}{10}$ part of carbonate of potassa, as prescribed by Liebig, does not produce a greater quantity, according to Henneberg's experience; but it may happen that, on application of too high a temperature, no mellonide of potassium is obtained, in consequence of ferrocyanide of potassium being regenerated. Henneberg supposes that the increased quantity obtained by Liebig is the result of the greater fusibility of the mixture effected by the carbonate of potassa, and proposes, therefore, to replace it by sulphocyanide of potassium, this being a very fusible salt and free from oxygen.

Products of Decomposition of Mellonide of Potassium.—On evaporating at a boiling heat, with repeated renewal of the water, 1 part of mellonide of potassium, 10 parts of solution of potassa of 1.2 spec. grav., and 20 parts of water, until the concentrated mass no longer solidifies to a cheesy, but to a crystalline mass, all the mellonide of potassium is decomposed with considerable disengagement of ammonia. The crystals are put on a funnel closed with asbestos, and first washed with potassa, then with alcohol, and recrystallized from boiling water, a little alcohol being added to the filtrate. On cooling, colourless, vitreous, prismatic needles, sometimes $\frac{1}{8}$ of an inch in length, of the potassa-salt of an acid are obtained, which has been called by Henneberg *cyameluric acid*. The salt possesses an alkaline reaction, tastes at first alkaline, then acridly bitter, dissolves in 7.4 parts of water at 18° and in from 1 to 2 parts of water at 100° , but is insoluble in alcohol. Its solution yields with chloride of barium and sulphate of magnesia a white and crystalline, by salts of copper a blueish-white and granular, and by neutral sesquichloride of iron a yellow, voluminous and amorphous precipitate; the silver-salt is caseous and not very soluble in dilute nitric acid. Cyameluric acid is separated from its salts by concentrated nitric or hydrochloric acids in the form of a white powder.

Products
of decom-
position of
mellonide
of potas-
sium.

From the analyses of the potassa-salt Henneberg calculated the formula $3 \text{ KO}, \text{C}_{12}\text{N}_7\text{HO}_3$ and $3 \text{ KO}, \text{C}_{12}\text{N}_7\text{O}_3$; he adopts, however, the former as the correct one, inasmuch as an amount of hydrogen in the salt could not be doubted, judging from its deportment on heating. The salt dried in the air loses from 13.86 to 14.03 per cent = 6 equivs. of water over sulphuric acid or at 120° ; it fuses at a gentle red-heat, always developing at the commencement ammoniacal, and then acid vapours; the crystalline residue emits the odour of cyanic acid when sulphuric acid is poured upon it.—The baryta-salt of the cyameluric acid, dried at from 100° to 120° , gave the formula $2 \text{ BaO}, \text{C}_{12}\text{N}_7\text{HO}_3 + \text{HO}$; at 250° it lost 1 equiv. of water (found 1.72, calculated 2.07 per cent.). The silver-salt dried at from 100° to 130° $3 \text{ AgO}, \text{C}_{12}\text{N}_7\text{HO}_3 + 2 \text{ HO}$.

Cyameluric acid, separated from the potassa-salt by hydrochloric acid, crystallizes from its hot ~~potassa~~ solution, to which a few drops of hydrochloric acid have been added, in white crusts, out of which the single crystals project. It dissolves in about 420 parts of water at 17° , and more easily in hot water. The acid stains considerably, reddens litmus and decomposes the carbonates when assisted by heat. Its compounds with ammonia and soda crystallize, like the potassa-salt, in needles, and are readily soluble in water. The ammonia-salt is decomposed in the air with formation of an acid salt. The formula of cyameluric acid dried at from 100° to 120° is, according to Henneberg, $\text{C}_{12}\text{N}_7\text{HO}_3, 3 \text{ HO}$; the crystallized acid contains besides 5 equivs. of water, (experiment 17.47, and calculation 16.85 per cent.).—By boiling cyameluric acid with nitric acid, a white, crystalline body is formed, which Henneberg considers to be cyanuric acid; at a moderate red-heat cyameluric acid is rendered yellow, vapours of the odour of cyanic acid escape, and a white sublimate, probably also cyanuric acid, is formed; the yellow residue is mellon.

On adding acetic acid to a moderately-concentrated, warm solution of the above potassa-salt, thin tables, iridescent in sunlight, are separated, consisting of acid cyamelurate of potassa. This salt is more soluble in water than the acid; it has an acid reaction, and when dried at from 120° to 130° , it possesses the formula $\text{KO}, 2 \text{ HO}, \text{C}_{12}\text{N}_7\text{HO}_3$; this salt, dried over sulphuric acid, contains besides 4 equivs. of water (found 12.08, calculated 12.16 per cent). When ignited its behaviour is similar to that of the acid; the yellowish-brown, fusible residue is soluble in water, insoluble in alcohol; acetic acid separates from its solution a slimy substance, and the filtrate contains mellonide of potassium.

On neutralizing the mother-liquor from which the cyamelurate of potassa has been deposited, with acetic acid, a copious precipitate is formed, which, after being washed first with cold, then with hot water, dissolved in ammonia and precipitated with acetic acid, exhibits all

the properties of ammelide, $C_{12}N_9H_9O_6$; this has been also verified by analysis. Hence this body is likewise a product of decomposition of mellonide of potassium by potassa.

Henneberg shows finally, that the salt previously obtained by Liebig(1) by boiling mellon with potassa, was nothing else than cyamelurate of potassa. He explains the decomposition of mellonide of potassium by potassa by the equation: $3(C_6N_4, K) + 11 HO + KO = C_{12}N_7HO_6, 3K + C_2HO_4, K + C_4H_3N_3O_2$ (equiv. of ammelide) $+ N_2H_6$. The presence of formic acid amongst the products of decomposition could, however, not be demonstrated with certainty.

Gerhardt(2) considers the formula of cyameluric acid adopted by Henneberg as incorrect; he assumes 2 equivs. of oxygen(=16) less and 1 equiv. of nitrogen(=14) more, and proposes in accordance with this, the following formulæ for cyameluric acid and those of its salts which have been examined, the calculated values of which must of course very closely agree with the numbers obtained by Henneberg for the carbon, hydrogen, and the metal:

Neutral potassa-salt: $C_{12}N_4HK_3O_4$.

	Calculated.	Found (Henneberg.)	
Carbon	21.56	21.62	21.56
Hydrogen	0.29	0.26	0.21
Potassa	42.21	41.91	42.16

Acid potassa-salt: $C_{12}N_4H_3KO_4$.

Carbon	27.90	27.22	
Hydrogen	1.16	1.00	
Potassa	18.21	18.05	18.10

Silver-salt: $C_{12}N_4HAg_3O_4$.

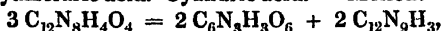
Carbon	13.30	13.07	13.17
Hydrogen	0.18	0.51	0.57
Silver	59.88	57.67	58.03

Dry acid: $C_{12}N_8H_4O_4$.

Carbon	32.73	32.00	32.08
Hydrogen	1.82	1.71	2.00

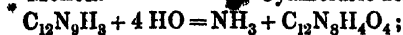
The transformation of cyameluric acid by dry distillation into mellon and cyanuric acid (or cyanic acid) observed by Henneberg, is explained by Gerhardt in the following equation (Laurent and Gerhardt's formula for the mellon, $C_{12}N_9H_3$ as basis):

Cyameluric acid. Cyanuric acid. Mellon.



and the formation of cyameluric acid from mellon and potassa, during which, in every instance, disengagement of ammonia was observed:

Mellon. Cyameluric acid.



(1) Ann. Ch. Pharm. XLIII, 98.

(2) Laur. and Gerh. C. R. 1850, 104; Compt. Rend. XXX, 318.

Products
of decom-
position of
mellonide
of potas-
sium.

mellon would accordingly be the imide of cyameluric acid. Ammelide (as Gerhardt assumes) $C_{12}N_8H_8O_8$ would be cyameluric acid, $C_{12}N_8H_4O_4 + 4$ equivs. of water.

Gerhardt is of opinion that the investigation of Henneberg establishes the formula $C_{12}N_9O_3$ for mellon and $C_{12}N_9HK_2$ for mellonide of potassium, especially since the disengagement of ammonia in the treatment with boiling potassa could not be explained if Liebig's formula of mellon and mellonide of potassium be adopted(1).

Kakodyl-Compounds.—The kakodyl-compounds contain, according to Laurent's view(2), a basic body, C_4H_5As , analagous to aniline, which would be the arsenamide of aldehyde: $C_4H_4O_2 + H_3As = C_4H_5As + 2 H_2O$. The compounds of kakoplatyl, the water of which does not escape by strongly drying them, are also salts of C_4H_5As , in which however platinum is substituted for hydrogen.

Acids and Collateral Matters. Mellitic Acid.—N. W. Fischer(3), in his investigations on the metamorphoses which mellitate of ammonia undergoes at various temperatures, has obtained results which are in accordance with those of Wöhler(4). He has found, besides, that cadmium and iron, if air be excluded, also separate euchron from euchronic acid. According to Fischer, when mellitate of ammonia is heated from 300° to 400° an amorphous, yellow body, of strongly bitter taste, sublimes together with a bluish-green one; the latter, he says, is soluble in boiling water, the first insoluble, both yield with the alkalis easily soluble, and with the oxides of the heavy metals insoluble compounds. On igniting the residue of the compounds heated to from 300° to 400° , colourless needles, insoluble in water, sublime, which are said to be soluble in ammonia only at a boiling heat, and to be separated again on cooling in the form of a crystalline powder. Fischer considers it possible that the blue, the yellow, and the colour-

(1) I consider the constitution of the radical contained in the mellon-compounds to be fully established by the formation and the analysis of the mellonide of potassium, and by the absence of hydrogen in this body; although I admit that the investigation of these compounds leaves much to be desired. The attempts to substitute for the formula given by me another expression deduced from indirect relations, which are considered as proofs, cannot induce me either to doubt the correctness of direct conclusions from perfectly definite, and to me indubitable facts, or to prove again, on my part, what I consider as fully established.—J. L.

(2) Compt. Rend. XXXI, 349; J. Pr. Chem. LI, 241.

(3) J. Pr. Chem. LI, 113. Laurent (Compt. Rend. XXXI, 354; J. Pr. Chem. LI, 245), contrary to the opinion of Wöhler and Schwarz (Annual Report for 1847 and 1848, I, 382), persists in viewing euchronic acid as an amidogen-acid.

(4) Ann. Ch. Pharm. XXXVII, 263.

less sublimates are isomeric compounds, inasmuch as the former yielded the latter on being rapidly heated to ignition, and the latter was changed into the former when slowly heated from 300° to 400° .

Oxalic
acid.

Oxalic Acid.—Rammelsberg(1) thinks it probable that, contrary to the general belief, a double salt of oxalate of potassa with oxalate of soda does not exist. On saturating a boiling solution of binoxalate of potassa with carbonate of soda, a crystalline pulverulent salt is precipitated as soon as the liquid becomes neutral (with a less concentrated solution only after evaporation); this salt is, however, no double salt, but merely the anhydrous oxalate of soda, $\text{NaO}, \text{C}_2\text{O}_3$, already examined. 1 part of this salt dissolves in 36.4 parts of water at the ordinary temperature, and in 24.6 parts of boiling water.

Fumaric Acid.—Delffs(2) recommends the following method for the preparation of fumaric acid from the juice of *Fumaria officinalis*, as being preferable to the former methods, according to which the fumarate of lead precipitated from the juice was decomposed by sulphuretted hydrogen. The juice, expressed with addition of a little water, is heated to boiling, the liquid separated from the coagulated mass, and from the sediment formed after standing for some time, is precipitated by acetate of lead, the yellowish-green precipitate, after having become more compact by being left undisturbed, is then washed, and dried in the air on filtering-paper; it is then triturated and gradually mixed with nitric acid, whereby a swelling of the mass and a feeble disengagement of nitrous vapours take place. After twenty-four hours the mixture of nitrate of lead and free fumaric acid is mixed with some water; filtered, the residue washed with a little water, and the fumaric acid extracted from the residue by alcohol of the usual strength; the alcoholic solution is evaporated, the residue dissolved in ammonia, the excess of ammonia driven off by heating, and the oxide of lead present removed by sulphuretted hydrogen (when colouring matter is also separated with the sulphide of lead) the bifumarate of ammonia is then crystallized, the crystals, if too much coloured, purified by pressing and recrystallizing, and from the solution of the salt in hot water the fumaric acid is separated by addition of nitric acid (which, when added in slight excess, generally destroys the colouring matter completely); the fumaric acid crystallizes on cooling, completely, however, only after some time has elapsed. From 20 lbs. of the plant, Delffs obtained in this manner upwards of 5 drachms of pure fumaric acid.—Bifumarate of ammonia crystallizes in monoclinometric prisms of about 70° and 110° , with terminal faces which are inclined at about 60° and 120° to the more acute edges of the prism; the crystals have a distinct cleavage parallel to these

(1) Pogg. Ann. LXXIX, 562; Ann. Ch. Pharm. LXXVI, 277 (in abstr.)

(2) Pogg. Ann. LXXX, 435.

Fumaric
acid.

terminal faces; sometimes these terminal faces are replaced by faces of a clinodiagonal doma. The crystals become opaque in dry air.

Pasteur(1) has found the acid ammonia-salt of fumaric acid prepared from *Fumaria officinalis* and of acid prepared from malic acid (so-called paramaleic acid) to possess the same crystalline form, viz. : a monoclinometric combination $\infty P. \infty P \infty .OP. - P(\infty P : \infty P$ in the orthodiagonal principal section $\angle 110^\circ$; $OP : \infty P \infty = 86^\circ 51'$; $-P : -P = 132^\circ 52'$.

Aconitic Acid.—Braconnot(2) discovered in *Equisetum fluviatile* a peculiar acid, to which he gave the name of *equisetic acid*; Regnault(3) found the same acid in *Equisetum limosum*, and considered it to be identical with maleic acid; Liebig(4), however, declared it to agree with aconitic acid.—Baup(5) has investigated this acid more carefully. He precipitated the juice of *Equisetum fluviatile*, from which the chlorophyll had separated spontaneously, with acetate of lead; he then decomposed the greyish precipitate, after being washed with water, by means of sulphuric acid, separated an astringent substance with gelatin and an amount of malic acid by carbonate of lime, dissolving the latter in the liquid, and evaporating to the consistence of a syrup, when acid-malate of lime separated on standing. He then precipitated again by acetate of lead, decomposed the precipitate formed by means of sulphuric acid, evaporated the liquid carefully, and then, on allowing it to stand quietly, he obtained the acid in the form of brown crusts which he purified by repeatedly crystallizing, treating with charcoal, and dissolving in ether(6). The purified acid is white, completely soluble in ether, at 12° soluble in twice its weight of alcohol of 88 per cent, at 15° in three times its weight of water; it requires less boiling water for solution, and separates from this on cooling in the form of white crusts. When slowly crystallized, transparent square tables are formed; the solutions are efflorescent.

(1) Ann. Ch. Phys. [3] XXXI, 91.

(2) Ann. Ch. Phys. [2] XXXIX, 5; Berzelius' Jahresber. IX, 210.

(3) Ann. Ch. Phys. [2] LXII, 208; Berzelius' Jahresber. XVII, 250.

(4) Liebig's Handbuch der organischen Chemie, 272.

(5) Ann. Ch. Phys. [3] XXX, 312; Ann. Ch. Pharm. LXXVII, 293; J. Pr. Chem. LII, 52 (in abstr.); a short notice of the results, Compt. Rend. XXXI, 387; Instit. 1850, 289; J. Pr. Chem. LI, 254.

(6) In the liquor which was poured off from the first greyish precipitate, produced by neutral acetate of lead, a copious yellow precipitate was formed on addition of tribasic acetate of lead, and after two days phosphate of lead was deposited in hard grains. The yellow precipitate, on being decomposed with sulphuric acid, produced an uncrystalline acid, resembling lactic acid, and a granular blackish substance, which when purified appeared to be a peculiar yellow colouring matter, and was termed by Braconnot, *Flavequisetin*. This is but little soluble in cold water, and separates in fine yellow flakes on cooling the hot aqueous solution; it is soluble in alcohol, and crystallizes from this solution; it is little soluble in ether, and imparts to cotton, mordanted with alum, a beautifully yellow colour.

When heated, the acid becomes brown, emits acid vapours, and leaves a copious carbonaceous residue. The solution of the acid is precipitated by acetate of lead and nitrate of suboxide of mercury, but not (except after neutralization) by nitrate of silver and nitrate of lead; salts of sesquioxide of iron strike a red colour with the solution of the free acid and precipitate the solutions of its salts in red, gelatinous flakes. The same properties have been observed by Baup in the acid of *Aconitum napellus*, and in the acid formed at the commencement of the decomposition of citric acid by heat, and called by him *citridic acid*; he does not doubt the identity of these acids, and terms them all aconitic acid. The aconitic acid differs however from maleic acid; the former is volatile, the latter not; the former yields with potassa a quadri-acid salt, the latter not, the solubility and crystalline form of both acids also differ. (Compare Dessaignes' remarks, page 256).—Baup farther communicates his investigations on the aconitates, from which we extract that portion which completes the statements of Buchner, Jun. (1)—*Potassa-salts*: On neutralizing a definite quantity of acid with potassa, and adding an equal amount of acid, a salt crystallizes first which is more acid than the biaconitate; from the mother-liquor, however, the latter crystallizes afterwards, $\text{KO}, 2\text{C}_4\text{HO}_3 + 2\text{HO}$; this salt is immediately obtained on neutralizing 1 part of acid with potassa, adding $\frac{1}{2}$ part of acid and crystallizing the liquor. It crystallizes in four-sided tables; on dissolving it in water. triaconitate of potassa separates in the form of a crystalline powder. The latter salt is also formed on neutralizing 1 part of acid with potassa and adding 2 parts of acid; it crystallizes in small three-sided tables which become opaque after some time without losing weight; it is $\text{KO}, 3\text{C}_4\text{HO}_3 + 2\text{HO}$, loses no water at 100° and is dissolved at 15° in 11 times its weight of water.—*Soda-salts*: Aconitate of soda is a hygroscopic, uncrystalline mass. Biaconitate of soda separates from a concentrated aqueous solution on addition of alcohol in the form of micaceous tables, and dissolves at 15° in twice its weight of water; when crystallized it is $\text{NaO}, 2\text{C}_4\text{HO}_3 + 5\text{HO}$, it effloresces in dry air, and then contains still $2\frac{1}{2}$ (according to Baup $2\frac{1}{3}$ equivs. of water; when dried at 100° it yet contains 1 H₂O which cannot be driven off without decomposition; the salt thus dried attracts again $1\frac{1}{2}$ equiv. H₂O when exposed to the air.—*Ammonia-salts*: Biaconitate of ammonia exhibits a deportment similar to that of the corresponding potassa-salt, as regards preparation and decomposition by water; it crystallizes in microscopic prisms $\text{NH}_4\text{O}, 2\text{C}_4\text{HO}_3 + \text{HO}$. The triaconitate crystallizes in three-sided tables, $\text{NH}_4\text{O}, 3\text{C}_4\text{HO}_3 + 2\text{H}_2\text{O}$, and dissolves in $6\frac{1}{2}$ times its weight of water of 15° .—The *lime-salt*, $\text{CaO}, \text{C}_4\text{HO}_3 + 2\text{HO}$ does not lose all its water of crystallization at 100° ; it dissolves in from 98 to 99 times its weight of water of 15° ; on evaporating the solu-

Aconitic
acid.

tion at a gentle heat an amorphous mass is formed; when, however, some crystallized salt is added, fine crystals are separated.—The *aconitate of protoxide of manganese* forms small, rose-coloured crystals, $\text{MnO}, \text{C}_4\text{H}_3\text{O}_3 + 4 \text{HO}$, which give with cold water a clear, with boiling water a turbid solution.

According to Dessaignes(1) fumarate, maleic, and aconitic acids exhibit the same deportment in this respect, viz.: that they yield succinic acid in the fermentation induced by casein (compare the subsequent statements); citrate of lime and of soda produce no succinic acid in this fermentation. Aconitic acid differs from fumaric and maleic acids; bifumarate and bimaleate of ammonia yield, by dry distillation, a substance similar to that generated under like circumstances from bimalate of ammonia, differing however from it, although it is likewise convertible into aspartic acid by continued action of hydrochloric acid. The acid ammonia-salt of the acid from *Aconitum* or *Equisetum* (Dessaignes recognized the acids in both plants as being identical) yield, on similar treatment, no aspartic acid. A farther difference between maleic and aconitic acids is, that sesquichloride of iron is not precipitated by maleate but by aconitate of ammonia.

Succinic Acid.—Neutral and acid malate of lime(2), malate of potassa, aspartate of potassa and of lime, fumarate of lime, maleate of lime and aconitate of lime, are all converted into succinates, according to Dessaignes, by the fermentation induced by casein. Aspartic acid is converted, under the same influence, first into aspartate of ammonia, which is then changed into succinate. The substance contained in the seeds of leguminous plants, which is converted into asparagin during germination(3), is also capable of being transformed into succinic acid by fermentation. If flour of peas be mixed with water, and the liquor filtered off after twelve hours and, mixed with some chalk, left to ferment, a considerable quantity of succinate of lime is formed. In order to discover from what substance the succinic acid is formed during this process, Dessaignes fermented separately legumin, the liquor poured off from it, and the nitrogenous body pointed out by Braconnot, which precipitates tannin; in all these cases succinic acid was formed, although in unequal quantities. Succinic acid was also obtained by Dessaignes on fermenting an emulsion of sweet

(1) Compt. Rend. XXXI, 432; J. Pharm. [3] XVIII, 254; J. Pr. Chem. LI, 247.

(2) The preparation of succinic acid by the fermentation of malate of lime has been mentioned in the Annual Report for 1849, III, 207. Bley (Arch. Pharm. [2] LXII, 13) and Gräber (Arch. Pharm. [2] LXIII, 137) have communicated their observations on this mode of preparing succinic acid.—According to G. Reich (Arch. Pharm. [2] LXII, 148; Ann. Ch. Pharm. LXXVI, 280), the acid residue of the distillation of *spirit. ætheris myrsini* from nitric acid and alcohol contains sometimes, in addition to oxalic and saccharic acids—a considerable quantity of malic acid, and can be used with advantage for the preparation of malate of lime and succinic acid.

(3) Compare Annual Report for 1847 and 1848, II, 116.

almonds, freed from oil and mixed with chalk.—Dessaigues(1) found farther, that succinic acid is formed by the oxydation of butyric acid. He heated 30 grammes of butyric acid with twice its bulk of nitric acid of 1.40 spec. grav. in such a manner that the vapours of the butyric acid were condensed and flowed back to the liquid, renewing also from time to time the nitric acid; disengagement of nitrous vapours ensued, but even after being continued for ten days, the action of the nitric acid was not completed. On distilling the liquid a crystalline residue of succinic acid was left behind contaminated with a deliquescent substance. The latter could be nearly removed by pressure between bibulous paper; the identity with succinic acid of the crystalline acid formed was established by an examination of its external properties, its reaction, and by an estimation of the amount of silver contained in the silver-salt.

Succinic
acid.

Tartaric Acid. Bitartrate of Potassa.—Schabus(2) has submitted to a closer investigation the crystalline form of bitartrate of potassa. For the type P of the right-rhombic crystals he finds: principal axis: macrodiagonal: brachydiagonal = 1 : 1.3565 : 0.9052; the more obtuse terminal edges = $125^{\circ} 46'$, the more acute terminal edges = $100^{\circ} 21'$, the lateral edges = $103^{\circ} 38'$, inclination of the more obtuse terminal edges to each other = $87^{\circ} 58'$, that of the more acute ones = $107^{\circ} 12'$, that of the lateral edges = $109^{\circ} 8'$. P is in most cases hemihedrally developed, and according to Haidinger's and Schabus' observations, sometimes the one sometimes the other hemihedral form derived from P predominates(3). Schabus observed combinations of the form

$+ \frac{P}{2}, - \frac{P}{2}, \infty P, \infty \bar{P} \infty$ (recognizable by the horizontal striæ),

$\bar{P} \infty, 2 \bar{P} \infty, 3 \bar{P} \infty, \infty \bar{P} 2$. Complete cleavage takes place parallel to OP and $\bar{P} \infty$. The spec. grav. of the crystals is 1.943.

Boro-tartaric Acid.—G. C. Wittstein(4) has made investigations on the preparation and the constitution of boro-tartrate of potassa and of boro-tartaric acid, with reference to the observations of Krug(5) and of Wackenroder(6). Wittstein draws the following conclusions from his experiments. Boracic acid does not chemically combine with tartaric acid without the intervention of a base; the deliquescence of a mixture of boracic and tartaric acids is caused by the former withdrawing water from part of the latter, and thus

(1) Compt. Rend. XXX, 50; Instit. 1850, 26; Ann. Ch. Pharm. LXXIV, 361.

(2) Wien. Acad. Ber. June, 1850, 42.

(3) This is a difference in form, as it should be exhibited in the acid potassa-salts of Pasteur's dextroracemic acid (tartaric acid) and levoracemic acid (see Annual Report for 1849, III, 209), the salts of the two acids, by the combination of which, racemic acid is formed.

(4) Rept. Pharm. [3] VI, 1.

(5) Annual Report for 1847 and 1848, I, 389.

(6) Annual Report for 1849, III, 208.

Boro-
tartaric
acid.

converting it into hygroscopic tartaric acid. 1 equiv. of borax does not convert more than 2 equivs. of tartar into easily soluble double salt, the composition of which, when it is dried, is $\text{NaO}, 2(\text{BO}_3 + \text{C}_4\text{H}_2\text{O}_5) + 2(\text{KO}, \text{C}_4\text{H}_2\text{O}_5)$. 1 equiv. of boracic acid does not convert more than 1 equiv. of tartar into easily soluble double salt, whose composition, when it is dried, probably is $\text{KO}, 2(\text{BO}_3 + \text{C}_4\text{H}_2\text{O}_5) + \text{KO}, 2\text{C}_4\text{H}_2\text{O}_5$. He designates as biboro-tartrate of potassa the amorphous, easily soluble mass, persistent in contact with the air, which is obtained when an aqueous solution of 20 parts of boracic acid and 30.39 parts of tartar is evaporated; and as biboro-tartrate of soda, the amorphous, easily soluble mass, attracting moisture in the air, which is obtained by evaporating an aqueous solution of 30 parts of borax and 23.57 parts of tartaric acid.—Neither boro-tartrate of potassa, nor boro-tartaric acid are precipitated by chloride of calcium; but after neutralizing these compounds by ammonia, chloride of calcium produces a voluminous precipitate, considered by Wittstein(1) as a double salt of tartrate of lime with boro-tartrate of lime, $3(\text{CaO}, \text{C}_4\text{H}_2\text{O}_5) + \text{CaO}, \text{BO}_3, \text{C}_4\text{H}_2\text{O}_5$.

Metamorphoses of Tartaric Acid by Heat.—Fremy's former statements as to the change of tartaric acid by heat, have been contradicted by Laurent and Gerhardt(2). According to the former, tartaric acid is thereby transformed into other acids, with loss of water; according to the latter, only a transposition of the atoms takes place, without loss of water. Fremy subjected to a new examination the change of tartaric and racemic acids by heat; but only the conclusions he draws from it were published during 1850(3). He finds his former results completely verified; his analyses and observations are in direct opposition to the views of Laurent and Gerhardt. At 170° , he says, the tartaric acid not only loses water, but a volatile acid is also formed therefrom; tartaric and racemic acids, when heated, are transformed, by the loss of water, and not merely by a transposition of the atoms, into other acids of a different capacity of saturation.

Racemic Acid.—Delffs(1) has made the following observation on instituting experiments to verify the observations on racemic acid made by Pasteur(5). On neutralizing equal quantities of racemic acid, procured from the discoverer of the acid himself (Kestner), with

(1) Rept Pharm [3] VI, 177.

(2) Comp. Annual Report for 1847 and 1848, I, 389.

(3) Compt. Rend. XXXI, 890; Instit 1851, 1; J. Pharm. [3] XIX, 81; Laur. and Gerh. C. R. 1850, 417; J. Pr. Chem. LII, 156 (the complete treatise [1851] Ann Ch. Phys [3] XXXI, 329, Ann Ch. Pharm LXXVIII, 297). Biot's remarks, who regards the view of Laurent and Gerhardt as the more probable one, see Compt Rend. XXXII, 3, Laur. and Gerh. C. R. 1850, 419; J. Pr. Chem. LII, 366; comp. also page 116 of this Report.

(4) Annual Report for 1849, III, 209.

(5) Pogg. Ann. LXXXI, 304.

potassa and with soda, and spontaneously evaporating the mixture of both solutions, crystals were deposited of the form of Rochelle salt, and differing from this only by their solution producing a slight precipitate in solution of gypsum. The mother-liquor of these crystals, and the crystals themselves, on being recrystallized, produced crystals of a different form (triclinometric), and of the composition $\text{K}_2\text{O}, \text{NaO}, \text{C}_8\text{H}_4\text{O}_{10} + 9 \text{HO}$; their solution did not rotate the plane of polarization. The crystals of the form of Rochelle salt could not be obtained again by Delffs(1).

Racemic acid.

Lactic Acid.—Strecker(2) has discovered the artificial formation of lactic acid, and a new body, homologous to glycocine.—The investigations of Engelhardt(3), Städeler(4), and Liebig(5), had shown that aldehyde occurs usually amongst the products of decomposition of lactic acid. Strecker thought it probable that lactic acid, $\text{C}_6\text{H}_6\text{O}_6$, might be a congregated compound of formic acid ($\text{C}_2\text{H}_2\text{O}_4$), and aldehyde ($\text{C}_4\text{H}_4\text{O}_2$), just as formobenzoic acid may be considered as a congregated compound of formic acid and the aldehyde of benzoic acid (oil of bitter almonds, $\text{C}_{14}\text{H}_6\text{O}_2$). Formobenzoic acid is formed by combination of oil of bitter almonds with formic acid in the nascent state. Strecker examined the products formed by the action of prussic acid on aldehyde. In a mixture of aldehyde-ammonia with aqueous hydrocyanic acid, the latter is rapidly decomposed, being perfectly destroyed after twelve hours, with separation of a brown powder, (paracyanogen). When the aqueous solution of aldehyde-ammonia, and hydrocyanic acid is immediately evaporated on the water-bath, a brown thick syrup is left, solidifying after some hours to a mass of fine needles, which may be obtained colourless by being pressed between bibulous paper, and recrystallized from boiling ether. This body is soluble in water, alcohol, and ether; the aqueous solution does not produce a precipitate with salts of silver; when treated with alkalis, it yields products of decomposition, amongst which

(1) The crystals of dextro-racemate of soda-potassa are Rochelle salt, and those of the levo-racemate of soda-potassa possess the same form as the former, with the sole difference that the small hemihedral faces occupy a different position. The solution of each of these double salts acts like that of Rochelle salt; a small quantity of mother-liquor enclosed (where the two acids are combined to racemic acid) produces the slight reaction of racemic acid. Mitscherlich already had found (Pogg. Ann. LVII, 484; Berzelius' Jahresber. XXIII, 332) that racemic acid forms a double salt with potassa and soda, which is not isomorphous with Rochelle salt. It remains as yet undecided whether the racemic acid is split into dextral and leval by the crystallization also of this double salt, whether two kinds of crystals are formed with differently placed hemihedral faces, and whether in this case a mixture of about equal quantities of both crystals produces an optically indifferent solution, or whether in a double salt with an amount of water different from that in Rochelle salt, the racemic acid is contained in an undecomposed state.

(2) Ann. Ch. Pharm. LXXV, 27; Chem. Gaz. 1850, 409; J. Pharm. [3] XVIII, 393; Laur. and Gerh. C. R. 1851, 36; a short notice of the results Compt. Rend. XXXI, 204; J. Pharm. [3] XVIII, 240.

(3) Annual Report for 1849, III, 212. (4) Annual Report for 1849, III, 213.

(5) Annual Report for 1849, III, note (2) p. 213.

Lactic
acid.

hydrocyanic acid, aldehyde and ammonia can easily be recognized. It is a base, or is converted by acids into a base, forming an easily soluble double salt with bichloride of platinum. Strecker expects to be able to give farther particulars respecting this body at some future period.—On mixing an aqueous solution of aldehyde-ammonia and hydrocyanic acid (2 parts of the former to 1 of the latter) with hydrochloric acid in excess, and heating the mixture, in a retort, not a trace of aldehyde passes over, but, besides hydrochloric acid, only a little hydrocyanic acid; and when concentrated hydrochloric acid is used, some formic acid. By evaporating the liquid in the retort (best in the water-bath) to half its original bulk, considerable quantity of chloride of ammonium crystallizes, and thick, strongly acid mother-liquor contains the hydrochlorate of substance which Strecker calls *Alanine*. In order to separate the hydrochlorate of alanine from the chloride of ammonium, the mass is freed as much as possible from the excess of hydrochloric acid by heating it to 100° for some time; it is then mixed with a little water, the undissolved chloride of ammonium filtered off, and washed with a small quantity of water. The filtrate is now freed from hydrochloric acid and chloride of ammonium by boiling with hydrated protoxide of lead, which is to be added until no farther disengagement of ammonia takes place. The basic chloride of lead thereby formed is filtered off, washed with boiling water, the filtrate freed from lead by sulphuretted hydrogen, and the liquid separated from the sulphide of lead made to crystallize, when alanine is deposited.

Alanine crystallizes, on the cooling of a warm saturated solution, in colourless bunches of needles (oblique rhombic prisms). On evaporating the aqueous solution, a skin is formed; and below this, feathery crystals. 1 part dissolves in 4.6 of water at 17° , and in a less quantity of hot water; it is soluble in about 500 parts of cold alcohol of 80 per cent, and not at all in ether. Its aqueous solution has a sweet taste, does not act on vegetable colours, and produces no precipitate with any of the usual reagents. It sublimes when heated beyond 200° , and falls down again in fine snow-like crystals. When rapidly heated, it melts with partial decomposition; when rapidly heated on platinum-foil, it burns with a violet flame. Its composition (when it is dried at 100° , or over sulphuric acid) is $C_6H_7NO_4$. Its formation from aldehyde and hydrocyanic acid, is explained by the equation, $C_4H_4O_2 + C_2NH + 2HO = C_6H_7NO_4$. It has the same composition as urethane, lactamide, and sarcosine. Urethane and lactamide differ from it, amongst other properties, in this, that they melt below 100° . Alanine more resembles sarcosine, but is less soluble in water, less volatile, and enters into combination with metallic oxides. This latter property, which is not possessed by sarcosine, proves that alanine, and not the isomeric sarcosine, belongs to the series of homologous substances, of which glycocine

($C_4H_5NO_4$) and leucine ($C_{12}H_{13}NO_4$) are members(1). — Alanine dissolves more readily in dilute acids than in water, which do not, however, thereby lose their action on vegetable colours; addition of alcohol to the solution causes no separation of alanine. On evaporating the solution of alanine in a volatile acid, a combination of alanine and acid remains behind, which exhibits a very acid reaction. The compounds of alanine and acids are more easily soluble in alcohol than free alanine, and in most instances also soluble in a mixture of alcohol and ether. Nitrate of alanine forms long colourless needles; dried at the ordinary temperature, $C_6H_7NO_4, HO, NO_5$, (the crystals, when dried over sulphuric acid, at first do not decrease in weight at 100° , but gradually become yellow and changed); it deliquesces in moist air, is readily soluble in water, and somewhat less so in alcohol. On passing dry hydrochloric acid gas over dry alanine, or by dissolving 2 equivs. of alanine in 1 equiv. of hydrochloric acid, a compound is formed, $2(C_6H_7NO_4) + HCl$, easily soluble in water, but little soluble in alcohol; it may be obtained in colourless needles. A compound $C_6H_7NO_4 + HCl$ (dried at 100°) is obtained, with difficulty in a state of purity, on evaporating a solution of alanine in an excess of hydrochloric acid; it is very deliquescent, and likewise easily soluble in alcohol. Neither the aqueous nor the alcoholic solution of hydrochlorate of alanine gives a precipitate with bichloride of platinum. On evaporating a solution of hydrochlorate of alanine, mixed with bichloride of platinum, treating the almost dry mass with a mixture of alcohol and a little ether, and allowing the solution to evaporate spontaneously, fine yellow needles are deposited, which (dried at the ordinary temperature) contain an amount of platinum corresponding to the formula $2(C_6H_7NO_4) + HCl + 2PtCl_2$. They are readily soluble in water, alcohol, and even in a mixture of alcohol and ether; they become dark-coloured at 100° , lose in weight, and leave, when dissolved in water, ammonio-chloride of platinum behind. Crystalline form and solubility distinguish this substance completely from the platinum-salt of sarcosine. Sulphate of alanine is readily soluble in water, and on evaporating the solution, a syrupy mass remains, which slowly solidifies to crystals. From the most concentrated aqueous solution, alcohol precipitates no sulphate of alanine; but a mixture of alcohol and ether precipitates the salt in the form of a thick syrup.—An aqueous solution of alanine is rendered dark-blue, when boiled with protoxide of copper; and on evaporation, dark-blue crystals are formed, which are readily soluble in water, but almost insoluble in alcohol. These are $C_6H_7NO_4, CuO$. They do not diminish in weight at 100° , but at 120° they are converted into $C_6H_6NO_3, CuO$;

Lactic acid.

(1) Gerhardt and Laurent (Annual Report for 1847 and 1848, II, 138) had arranged in one series: glycocine, sarcosine and leucine.

Lactic
acid.

assuming thereby a light-blue colour, and yielding a bluish-white powder. On boiling alanine with oxide of silver and water, the colourless liquid obtained deposits, on cooling, yellowish needles, grouped to semi-globular masses, which are $C_6H_6NO_3, AgO$, when dried at the ordinary temperature, or at 100° . They dissolve readily in water, and the solution can be boiled without undergoing decomposition; exposed to the air, they assume gradually a dark colour, as also when heated to 100° for some time whilst moist, (but not when dry). An aqueous solution of alanine, when boiled with protoxide of lead, deposits, on being evaporated and cooled, or on the addition of alcohol, colourless needles, which appear to be $2(C_6H_6NO_3, PbO) + PbO, HO + 5 HO$. They lose 5 equivs. HIO at 100° ; disintegrate, when dried over sulphuric acid, into a white powder, no longer completely soluble in water. An aqueous solution of alanine, on being boiled with carbonate of baryta, takes up a considerable quantity of baryta; and on evaporation, a compound of alanine with baryta crystallizes, yielding with water a solution of an alkaline reaction. Carbonic acid precipitates from this solution baryta, which, after boiling for some time, is redissolved.—Strecker leaves it undecided whether alanine enters into combination with nitrates, corresponding to the compounds of glycocine and leucine. Alanine combines with nitrate of silver; a solution of nitrate of silver and alanine in excess leaves on evaporation a residue, from which alcohol dissolves the compound, the excess of alanine remaining behind; on gently evaporating the solution, the compound is deposited in the form of colourless rhombic tables. On saturating nitrate of alanine with protoxide of copper, blue crystals, insoluble in alcohol, are obtained, which appear to be a compound of nitrate of copper with protoxide of copper and alanine.

Alanine dissolves in concentrated sulphuric acid, and even on boiling the solution no charring or disengagement of sulphurous acid takes place. It is not changed by boiling with potassa; on evaporating the liquor, ammonia and hydrogen are given off only when it is concentrated nearly to hydrate of potassa. If the operation be interrupted at this moment, and the mass distilled with sulphuric acid, hydrocyanic and another acid, apparently acetic, pass over along with the water. On heating the aqueous solution with binoxide of lead, alanine is decomposed into carbonic acid, aldehyde, and ammonia; as also on boiling alanine with binoxide of lead and dilute sulphuric acid (most likely with formation of some acetic acid from the aldehyde). On passing nitrous acid (prepared from starch and nitric acid, and freed from nitric acid as much as possible) into an aqueous solution of alanine, nitrogen is disengaged; when the alanine is completely decomposed, the nitrous acid is converted into nitric oxide and nitric acid. The strongly acid liquor, on being concentrated to the consistence of a syrup at a gentle heat, yielded

to ether an acid which remained after evaporation of the ether, and which was proved to be lactic acid. The salt of oxide of zinc had the composition, $\text{ZnO}, \text{C}_6\text{H}_5\text{O}_5 + 3 \text{HO}$; of the two modifications of lactic acid(1), therefore, that one was formed which is obtained from sugar. The formation of alanine from lactic acid is explained by the equation $\text{C}_6\text{H}_7\text{NO}_4 + \text{NO}_3 = \text{C}_6\text{H}_6\text{O}_6 + 2 \text{N} + \text{H}_2\text{O}$; in this instance, as in former experiments of Piria(2) and of Strecker(3), 2 O replace NH in the nitrogenous body under the action of nitrous acid.—In addition, Strecker points out that the other aldehydes belonging to the acids $\text{C}_n\text{H}_n\text{O}_4$ would most likely yield, with hydrocyanic acid, compounds corresponding to alanine.

Lactic acid.

Gallic and Tannic Acids, and their Correlatives.—Laurent(4) considers it probable that the substances similar to gallic and tannic acids might be arranged in homologous series with the following formulæ:

Gallic acid	$\text{C}_{14}\text{H}_6\text{O}_{10}$	Catechin-tannic acid	$\text{C}_{78}\text{H}_{10}\text{O}_{10}$	Tanno-caffeic acid	$\text{C}_{20}\text{H}_{12}\text{O}_{10}$
Tannic acid	$\text{C}_{14}\text{H}_6\text{O}_{10}$	Catechic acid	$\text{C}_{18}\text{H}_{10}\text{O}_{10}$		
Pyrogallic acid	$\text{C}_{12}\text{H}_6\text{O}_6$	Pyrocatechin	$\text{C}_{16}\text{H}_{10}\text{O}_6$		

Caincic Acid.—François, Pelletier, and Caventou(5), had discovered in the cainca-root (of *Chiococca racemosa*) a peculiar substance termed *caincic acid*. Liebig(6) found the (dry) uncombined substance to be composed in the atomic proportions of $\text{C}_8\text{H}_7\text{O}_4$. Rochleder and Hlasiwetz(7) have resumed the examination of this root and its acids, and obtained the following results. This root contains in the ligneous part but few soluble substances; the greater portion of these exist in the bark. The bark contains tanno-caffeic acid(8) and caincic acid (*Chiococca racemosa* and *Coffea arabica* belong to the same family, viz.: that of the *Rubiaceæ*). By extracting the bark of the root with boiling alcohol, and adding to the filtrate an alcoholic solution of acetate of lead, a yellow precipitate is formed, containing tanno-caffeate and caincate of lead, along with the lead-salts of phosphoric and other inorganic acids. The liquid filtered off from the precipitate yields, with tribasic acetate of lead, a pale yellow precipitate of caincate of lead, mixed with a little tanno-caffeate of lead. By decomposing the former precipitate with sulphuretted hydrogen, partially precipitating the liquid thus obtained with acetate of lead, and frequently repeating this process, the authors succeeded in obtaining a compound of tanno-caffeic acid with lead

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- (1) Comp. Annual Report for 1847 and 1848, I, 397.
 (2) Ibid. II, 115. (3) Ibid. I, 450.
 (4) Compt. Rend. XXXI, 352; J. Pr. Chem. LI, 243.
 (5) Ann Ch. Phys. [2] XLIV, 296; Berzelius' Jahresber. XI, 222.
 (6) Pogg. Ann. XXI, 33; Berzelius' Jahresber. XI, 224.
 (7) Wien. Acad. Ber. June, 1850, 6; J. Pr. Chem. LI, 415; Ann. Ch. Pharm. LXXVI, 338 (in abstr.); Chem. Gaz. 1851, 121.
 (8) Comp. Annual Report for 1847 and 1848, I, 400.

Caincic acid.

free from caincic acid, containing 25·66 per cent of protoxide of lead, 40·83 per cent of carbon, and 4·11 of hydrogen; accordingly, Rochleder and Hlasiwetz consider that the organic substance combined with the protoxide of lead has a composition corresponding to the formula $C_{28}H_{17}O_{15} = C_{14}H_8O_7 + C_{14}H_8O_7, HO$; ($C_{14}H_8O_7$ is the formula of tanno-caffeic acid in combination with bases). The acid separated from this compound possesses all the properties of tanno-caffeic acid from coffee.—The caincic acid is obtained when the second of the above precipitates (the pale-yellow one obtained with tribasic acetate of lead) is decomposed by sulphuretted hydrogen; and the filtrate slightly evaporated. The liquid being left to stand quietly, a flocculent precipitate of microscopic prisms is formed, which is purified by washing with a little cold water, pressing and repeated crystallization from a small quantity of boiling water, mixed with a little alcohol. Caincic acid thus prepared, forms a white, silky mass, consisting of small felted needles; it is soluble in water and spirits of wine; the solution is not coloured by salts of sesquioxide of iron; it yields purely white precipitates with salts of protoxide of lead, and is not changed by the alkalis. The acid, dried at 100° , had a composition corresponding to the formula $C_{16}H_{13}O_7$. The alcoholic extract of bark of the root contains a little lime, which passes over into precipitates formed by lead-salts, and, after their decomposition with sulphuretted hydrogen, into the liquid. When this liquid is evaporated in the water-bath to the consistence of a syrup, and a large quantity of absolute alcohol is added, a white flocculent substance is precipitated, which (dried at 100°) was found by Rochleder and Hlasiwetz to be composed according to the formula $4 CaO, 13 C_{16}H_{13}O_7 + 15 HO$. The precipitate obtained from an alcoholic solution of caincic acid by means of an alcoholic solution of acetate of lead is, (when dried at 100°), according to them, $PbO, C_{16}H_{13}O_7$; that produced by the tribasic acetate, $5 PbO, 3 C_{16}H_{13}O_7 + 3 HO$. In almost all the analyses, however, less hydrogen was found than the formulæ adopted by Rochleder and Hlasiwetz require.—On heating caincic acid with a very concentrated solution of potassa, the mass assumes a yellow colour, with frothing and disengagement of gas; from the aqueous solution of this mass acetic acid precipitates a gelatinous substance, carbonic acid being disengaged at the same time. This substance is obtained in larger quantities, and in a state of greater purity, by treating an aqueous solution of caincic acid with dilute acids. The liquid is rendered muddy or slimy on being heated; and on the addition of water, gelatinous flakes are deposited, easily soluble in alcohol, insoluble in water; they were termed *chiococcic acid*. In order to purify this acid, it was dissolved in boiling dilute alcohol; the substance, separated on cooling, was pressed, and this process repeated until the alcoholic solution became colourless. Such a solution is precipitated by water, like gelatinous

silicic acid. Acetate of lead yields with it a precipitate, the composition of which (when it is dried at 100°) corresponds to the formula $9 \text{ PbO}, 16 \text{ C}_{12}\text{H}_9\text{O}_3$. The composition of the acid itself dried at from 100° to 120° , corresponds to the formula $\text{C}_{48}\text{H}_{35}\text{O}_{11} = 4 \text{ C}_{12}\text{H}_9\text{O}_3 - \text{HO}$, that of another portion of acid, prepared from pure cainic acid, to the formula $\text{C}_{12}\text{H}_9\text{O}_3$. On heating chicoccic acid, a small quantity of brilliant crystals sublimes, and then a thick oil, of the odour of frankincense (olibanum) and petroleum, distils over.—By protractedly heating cainic acid with dilute sulphuric acid in the water-bath, neither carbonic acid nor inflammable gas was given off; the liquid separated from the jelly thus formed, treated with baryta-water, the filtrate freed from the excess of baryta by means of carbonic acid, and evaporated, a sweetish residue of a slightly yellow colour was left, which, on heating, emitted the odour of burnt sugar, and behaved towards sulphate of copper and potassa like grape-sugar. Rochleder and Illasiwetz consider, according to these observations, cainic acid to be a compound of chicoccic acid with a hydrate of carbon which, by the action of acids, is transformed into grape-sugar.

Cainic
acid.

Ipecacuanhic Acid.—Pelletier(1) had found in the root of *Cephaelis ipecacuanha*, besides some fatty matter and traces of an essential oil, gum, starch, pectin, emetine, ligneous fibre and a peculiar acid which he supposed to be gallic acid, but which was considered by Pfaff as differing from it. Willigk(2) has made the following observations during his investigations on this root. The pounded root was boiled with water, the brownish liquid, of a nauseous odour, strained through linen, diluted with water and filtered through paper; on the filter starch and pectin remained. Neutral acetate of lead precipitated from the filtrate chiefly phosphoric acid. The liquid filtered off, yielded with tribasic acetate of lead a precipitate which was decomposed by sulphuretted hydrogen; the sulphide of lead was separated and, on addition of a considerable quantity of alcohol to the evaporated liquid, gum separated (dried at 100° its composition was $\text{C}_{12}\text{H}_{10}\text{O}_{10}$), whilst *ipecacuanhic acid* remained in solution. The liquid, separated from the precipitate formed by tribasic acetate of lead, contained gum and emetine. In order to prepare ipecacuanhic acid, Willigk boiled the root with alcohol of 0.840 spec. grav., precipitated the alcoholic extract with tribasic acetate of lead, treated the precipitate with dilute acetic acid, again precipitated the solution by means of tribasic acetate of lead, and the filtrate from this precipitate with some ammonia; both precipitates

(1) Ann. Ch. Phys [2] IV, 172

(2) Wien Acad. Ber. July, 1850, 190, J. Pt. Chem. LI, 124, Ann. Ch. Pharm. LXXVI, 342 (in abstr.), Chem. Gaz. 1851, 131.

Ipe-
cacuanhic
acid.

were washed with alcohol, suspended in ether and decomposed by sulphuretted hydrogen; the ether of these solutions of the acid was then distilled off in an atmosphere of carbonic acid, the residue extracted with water, the aqueous solution digested with animal charcoal, and evaporated to dryness in an atmosphere of carbonic acid. The residue consisted of ipecacuanhic acid which, dried at 100° , was an amorphous, reddish-brown mass, of bitter taste, very hygroscopic, soluble in water, alcohol and ether, and of a composition corresponding to the formula $C_{14}H_9O_7$. The aqueous solution produced no precipitate with neutral acetate of lead, but a white one with the tribasic acetate, which assumed a darker tint on being exposed to the air and on drying; with sesquichloride of iron the acid produced a green, on addition of ammonia, a violet colour, and gave, on adding an excess of ammonia, a brownish-black precipitate. It also reduced the salts of silver and of mercury. The solution of the acid treated with alkalis blackened in the air with absorption of oxygen. Willigk examined various compounds of protoxide of lead which he prepared by different methods not easily described in a short notice; he obtained by the same method, however, compounds of very varying compositions. He ascribes the following formulæ to the lead-compounds examined by him (they were dried at 100°):

1. $PbO, C_{14}H_9O_6 + HO$
2. $5 PbO, 6 C_{14}H_9O_6 + 4 HO$
3. $PbO, 2 C_{14}H_9O_6 + HO$
4. $7 PbO, 6 C_{14}H_9O_6 + 6 HO$.

Crenic and Apocrenic Acids.—Winckler(1) has communicated, that in that portion of the pipe of a pump of fir-wood, which remained for a considerable time just above the water, an appreciable quantity of crenic and apocrenic acids was formed, the former chiefly in the inner, the latter chiefly in the outer layers of the changed wood.

Bromo-benzoic Acid.—Müller(2) has communicated as an objection to the theoretical views of Laurent, that by the action of bromine on dry benzoate of silver and subsequent distillation, a volatile acid was obtained, identical with the bromo-benzoic acid of Pélignot(3); he explains this by the equation $AgO, C_{14}H_6O_3 + 2 Br = C_{14}H_{4\frac{1}{2}}Br_{\frac{1}{2}}O_4 + AgBr + \frac{1}{2} HBr$; $C_{14}H_{4\frac{1}{2}}Br_{\frac{1}{2}}O_4$ he considers to be the formula of anhydrous bromo-benzoic acid, in which, however, the sum of the atoms of hydrogen and bromine is not divisible by 2. Laurent(4) throws doubt on the correctness of the formula, and communicates afterwards(5) that, according to a new investigation of Pélignot, the

(1) Jahrb. Pr. Pharm. XX, 10. (2) Compt. Rend. XXX, 325; Instit. 1850, 92.
(3) Berzelius' Jahresber. XVII, 251. (4) Compt. Rend. XXX, 339.
(5) Compt. Rend. XXXII, 11; Instit. 1851, 11.

composition of bromo-benzoate of silver is $\text{AgO}, \text{C}_{14}\text{H}_4\text{BrO}_3$, when bromo-benzoic acid will have the formula $\text{C}_{14}\text{H}_5\text{BrO}_4$.

Cinnamic
acid.

Cinnamic Acid.—Cinnamic acid crystallizes, according to Schabus(1), in prisms or tables of the monoclinometric system $\infty \text{P} . (\infty \text{P} \infty) . (\text{P} \infty)$; principal axis: clinodiagonal: orthodiagonal = 1 : 2.7220 : 3.1686; angle of the two latter $82^\circ 58'$; in the clinodiagonal principal section $\infty \text{P} : \infty \text{P} = 99^\circ 6'$, $(\text{P} \infty) : (\text{P} \infty) = 145^\circ 13'$; remarkable cleavage parallel to $(\infty \text{P} \infty)$; spec. grav. = 1.195.

Picric Acid.—According to Schabus(2), picrate of potassa exhibits the rhombic combination $\infty \text{P} . \infty \check{\text{P}} \infty . \check{\text{P}} \infty (\infty \text{P} : \infty \text{P} = 110^\circ 15' 30''$; $\check{\text{P}} \infty : \check{\text{P}} \infty$ in the brachydiagonal principal section = $139^\circ 25'$; proportion of the principal axis to the secondary axes = 1 : 2.70456 : 1.88469).

Formic Acid.—Formate of strontia ($\text{SrO}, \text{C}_2\text{HO}_3 + 2\text{HO}$) crystallizes, according to Pasteur(3), in the rhombic system, in the combination $\infty \text{P} . \infty \check{\text{P}} \infty . \check{\text{P}} \infty . \frac{\text{P}}{2}$; $\infty \text{P} : \infty \check{\text{P}} = 117^\circ 3'$; $\check{\text{P}} \infty : \check{\text{P}} \infty$ in the brachydiagonal principal section = $118^\circ 20'$; $\frac{\text{P}}{2} : \check{\text{P}} \infty = 143^\circ 16'$; $\frac{\text{P}}{2} : \infty \check{\text{P}} = 143^\circ 42'$. In some crystals a face $\frac{\text{P}}{2}$ is exhibited (the prism being placed in a certain position) in the upper part in front to the right hand, in others; occupying the same position, to the left; one form of crystals produces, on recrystallization, only crystals of the same form(4).

Acetic Acid.—Schabus(5) has found in the quadratic crystals of acetate of protoxide of copper and lime ($\text{P} . \text{O P} . \infty \text{P} . \infty \text{P} \infty$), the terminal edges of $\text{P} = 108^\circ 38'$; the lateral edges = $111^\circ 10'$, the principal axis = 1.0319. The crystals cleave readily parallel to ∞P and $\infty \text{P} \infty$; their spec. grav. is 1.4206.

Meyer(6) has made some communications on the preparation of a *Tinctura ferri acetici ætherea*, which can be preserved.

According to Löwig and Schweizer(7), when an intimate mixture of 2 parts of completely desiccated neutral acetate of lead with 1 part of dry so-called Parisian blue is gently heated, much gas (about 2

(1) Wien. Acad. Ber. July, 1850, 206.

(2) Wien. Acad. Ber. November, 1850, 390.

(3) Ann. Ch. Phys. [3] XXXI, 98.

(4) The crystals assume a quadratic habitus when the faces ∞P and $\check{\text{P}} \infty$ are equally developed, on account of the close approximation of the angles; this is the cause that these crystals were formerly described as quadratic pyramids P (of 118° lateral edge) with O P and $\frac{\text{P} \infty}{2}$.

(5) Wien. Acad. Ber. June, 1850, 59.

(6) Pharm. Centr. 1850, 382.

(7) Ann. Ch. Pharm. LXXV, 350; J. Pr. Chem. L, 341; Laur. and Gerh. C. R. 1850, 397; Chem. Gaz. 1850, 423.

Acetic
acid

vols. of carbonic acid to 1 vol. of carbonic oxide) is soon disengaged, whilst at the same time an ethereal distillate passes over; afterwards, at a red-heat, a yellow oil distils, a large quantity of carbonate of ammonia escaping and a pyrophoric residuë remaining behind. The ethereal distillate is miscible with water, ether and alcohol in all proportions; purified by shaking with phosphoric acid, and rectified first over protoxide of mercury and then over chloride of calcium, it was colourless, limpid, inflammable, and of a spec. grav. of 0.790 at 15°. Its boiling-point was first 69°, rapidly rose to 71°, then to 80°, and ultimately to 83°. The composition of the portion distilling at 71° corresponded to the formula $C_{10}H_9NO_2$, that of the portion distilling at 80° to C_7H_7NO . Lowig and Schweizer consider the former to be a mixture of 2 equivs of acetone (C_3H_6O) with 1 equiv. of acetonitrile (C_2H_3N), the latter a mixture of 1 equiv. of acetone and 1 equiv. of acetonitrile. A solution of potassa did not act upon it in the cold, but decomposed it when heated into ammonia and acetic acid, potassium decomposed it with formation of cyanide of potassium.

Acetone—Hlasiwetz (1) has communicated investigations on the action of bisulphide of carbon and ammonia on acetone. According to him, acetone forms a definite compound with chloride of calcium and water, powdered chloride of calcium and rectified acetone become first pulpy, then hot and form a dry mass which, when heated to 100°, emits traces of a liquid with an ethereal odour; on addition of more water, pure acetone passes over at 80° to 83°.—On mixing acetone with an equal bulk of bisulphide of carbon and about twice its bulk of ammonia, foliated, ice-like crystals are formed, after a few days, in the lower layer of the liquid, these disappear again after some time, and larger yellow crystals are formed. The latter are insoluble in water, slightly soluble in ether, soluble only with decomposition in warm alcohol and boiling hydrochloric acid. Dried *in vacuo*, they exhibit a composition expressed by the formula $C_{30}H_{26}N_3S_9$, Hlasiwetz considers them as sulphocarbamate of sulphacetyl with sulphocyanide of acetyl; $2(C_6H_6S), C_2H_2NS_3 + 2(C_6H_6S, CyS_2)$. A cold alcoholic solution of this compound gives, with a cold alcoholic solution of bichloride of platinum, a brownish-yellow uncrystalline, and with a cold alcoholic solution of protochloride of mercury, a white precipitate. Hlasiwetz ascribes to the former (when dried at 100°) the formula $C_{30}H_{26}N_3S_9 + 3PtS_2$; and to the latter, $C_{30}H_{26}N_3S_9 + 27HgS, 18HgCl$. On boiling the former compound with potassa, it yields oxide of mesityl, ammonia being disengaged. On being heated to the fusing-point, two layers are formed, the lower one containing acetone and bisulphide of carbon, the upper one much sulphide of ammonium; at the same

(1) Wien Acad Ber July, 1850, 171 J Pt Chem LI, 355 Ann Ch Pharm LXXVI, 294 (in abstr)

time a small quantity of white needles sublimes. On boiling the above compound with alcohol, ammonia and carbonic acid escape, with formation of sulphide of ammonium; a small quantity of a crystalline compound then separates, which, dried *in vacuo*, possesses the formula $C_{36}H_{36}N_5S_6$, and which is considered by Illasiwetz as acetonylamide with sulphocyanide of acetonyl, $2(C_6H_6, NH_2) + 3(C_6H_6, CyS_2)$.—A compound designated as hydro-sulphide of sulphide of acetonyl was obtained by Illasiwetz by the dry distillation of sulphomesitylate of lime with proto-sulphide of potassium, saturating the distillate with chloride of calcium, removing the oil not taken up by the chloride of calcium, and distilling the mass containing the chloride of calcium; he thus obtained a colourless oil, with an odour of onions, to which he ascribes the formula $3C_6H_6 + S + 11S + 8HIO$; he assigns a similar composition to oils of other preparations or prepared with penta-sulphide of potassium. The former oil mixed with bichloride of platinum in alcoholic solutions yielded—after the precipitate of sulphide of platinum immediately formed was filtered off, and on being mixed with water, and heated—a precipitate to which, after being dried at 100° , the formula $2C_6H_5Cl, 3PtCl + 8C_6H_5S, PtS + 7PtS_2$ was assigned. The oils described may be deprived of their sulphur by continued agitation with potassa and protoxide of mercury.

Propionic (Metacetic) Acid.—Propionic acid, in predominating quantity, is formed, according to F. Keller(1), on fermenting bran with animal tissues. Wheaten bran is made into a paste with 10 times its weight of water of 50° or 60° , mixed with $\frac{1}{4}$ of coarsely divided leather refuse, and, after the addition of some chalk, left to ferment in a warm place; the spongy, swelled mass having subsided (in summer after some days, in winter after some months), is strained, washed, the liquid saturated with carbonate of soda and evaporated; the acid formed is then separated from the residue by means of sulphuric acid. On partially saturating the acid thus obtained and distilling(2), this residue proves to be a mixture of acetate and propionate of soda. No other acid could be found.—Propionate of baryta, dries up to a gum-like mass, swelling after some time into bunches like cauliflower, efflorescent in the air; it contains 9 atoms of water of crystallization, which it loses on being heated to 140° . The soda-salt could only once be obtained in a crystallized form on being fused and dissolved in as little water as possible.

Valeric Acid.—A. W. Hofmann(3) has investigated the decomposition of valeric acid by heat. On passing the vapour of valeric acid through a red-hot tube, fluid products are formed the quan-

(1) Ann. Ch. Pharm. LXXIII, 205.

(2) On this method of separating these acids, see Annual Report for 1849, III, 227.

(3) Chem. Soc. Qu. J. III, 121; Ann. Ch. Pharm. LXXVII, 161; J. Pharm. [3] XVII, 170 (in abstr.); Laun. and Gerh. C. R. 1850, 225.

Valeric
acid.

tity of which changes according to the heat employed; they are accompanied by much gas. The latter contains carbonic acid, carbonic oxide and carbonetted hydrogens, C_mH_m , in some experiments possibly marsh-gas. By absorbing the carbonetted hydrogens, C_mH_m , by means of bromine-vapour, an oily liquid is obtained, which begins to boil at 130° and the greater part of which distils over between 136° and 156° ; the rectification of this distillate produces a fluid boiling between 143° to 145° , the composition of which very closely approximates to that of $C_6H_6Br_2$ (Reynolds' hydrobromate of bromide of propionyl, Cahours' dibromopropylene). The bromine-compound, passing over at a low temperature, is $C_4H_4Br_2$, judging from the boiling-point and the amount of bromine in it. The compound $C_6H_6Br_2$ most likely has some $C_8H_8Br_2$ admixed; this could, however, not be proved with certainty, from want of material. The carbonetted hydrogens formed by the above decomposition of valeric acid are, therefore, olefiant-gas C_4H_4 , propylene C_3H_6 , and perhaps butylene C_4H_8 . Valeric acid shows, consequently, a different deportment to that of acetic and benzoic acids which, under similar circumstances, lose simply $2 CO_2$. By an analogous deportment, valeric acid would yield a carbonetted hydrogen C_8H_{10} ; this, however, is not found amongst the products of decomposition, but is converted into more constant carbonetted hydrogens by the high temperature, whilst the excess of hydrogen appears in the marsh-gas or in the water formed by the reduction of carbonic acid to carbonic oxide. Hofmann points out that also in the distillation of margaric acid (with or without lime) and generally speaking of the acids $C_nH_nO_4$, of a high atomic weight, no carbonetted hydrogens are formed analogous to marsh-gas, but C_mH_m (comp. Cahours, page 273.)

Caproic Acid.—J. S. Brazier and G. Gossleth(1) have published investigations on caproic and cœnanthylic acids.

The caproic acid was prepared after the method of Frankland and Kolbe(2) by decomposing cyanide of amyl with an alcoholic solution of potassa. They employed impure cyanide of amyl; by distilling dry sulphamylate of potassa with $\frac{1}{3}$ of its weight of cyanide of potassium of commerce, they obtained a distillate containing much hydrocyanic acid; its boiling-point rose from 125° to 150° ; the portion passing over between 130° and 150° , containing besides cyanide of amyl, hydrated oxide of amyl, cyanate and cyanurate of oxide of amyl (the two latter, on account of the commercial cyanide of potassium containing cyanate of potassa), was kept boiling for half-an-hour with alcoholic solution of potassa, whereby much ammonia was disengaged. From the residue there was separated by distillation, ammonia,

(1) Chem. Soc. Qu. J. III, 210; Ann. Ch. Pharm. LXXV, 249; J. Pharm. [3] XVIII, 451.

(2) Annual Report for 1847 and 1848, I, 430.

alcohol, amylamine (formed from cyanate and cyanurate of amyl) and hydrated oxide of amyl (from the distillate considerable quantities of amylamine could be obtained, the boiling-point of which was found to be constant at 93°), and from the remaining solution of caproate of potassa the caproic acid was separated by means of sulphuric acid. The acid thus obtained had a boiling-point rising from 198° to 211° ; the first portion passing over was pure acid, and boiled constantly at 198° ; the last portion freed from admixed caproic acid by means of carbonate of potassa proved to be caproate of oxide of amyl, $C_{10}H_{11}O$, $C_{12}H_{11}O_3$, by analysis and by its decomposition with an alcoholic solution of potassa; it possesses a constant boiling-point of 211° , is lighter than water, of a disagreeable odour and an acid taste, insoluble in water, soluble in alcohol and ether in every proportion. The formation of caproate of oxide of amyl is caused by hydrated oxide of amyl being slightly soluble in caproate of potassa and by the application of sulphuric acid for the separation of caproic acid.—Caproate of baryta is very soluble in water, and separates from its solution in the form of crystalline tables on gentle evaporation *in vacuo* or over sulphuric acid; on boiling the solution an odour of caproic acid is given off, and a white mass separates which can be dried at 100° without undergoing decomposition. When heated more strongly it fuses and is decomposed, carbonic acid and inflammable gas escaping, and but a small quantity of liquid distilling over; the more rapidly the heating takes place, the more copiously the inflammable gas is disengaged, the smaller and browner is the liquid passing over, and the more carbon is mixed with the remaining carbonate of baryta. The liquid has a boiling-point rising from 120° to 170° ; the portion distilling between 120° and 160° appears to contain besides caprone also caprale ($C_{12}H_{12}O_3$, the aldehyde of capronic acid). The larger portion passes over between 160° and 170° , and when purified by rectification with hydrated potassa has a constant boiling-point at 165° and the composition $C_{11}H_{11}O$; it is *caprone*, a very mobile liquid, insoluble in water, readily soluble in alcohol and in ether, specifically lighter than water, and rapidly becoming brown in the air. Caprone is rapidly acted upon by strong nitric acid. The disengagement of red vapours having ceased, the liquid was saturated with carbonate of potassa, when a small portion of an aromatic oil separated; by distilling the alkaline liquid with sulphuric acid, an acid distillate was obtained, which yielded a white silver-salt, the amount of silver in which (42.24 per cent) corresponded to nitro-valcrate of silver. Formation of caproic acid was not observed by the action of nitric acid on caprone.—Brazier and Gossleth farther investigated the decomposition of a concentrated solution of caproate of potassa by 6 elements of a Bunsen carbo-zinc battery. The gases disengaged were chiefly carbonic acid and hydrogen; an oily liquid boiling at from 125° to 160° , was also separated, which was distilled with alcoholic solution of potassa.

œnanthylic acid.

Caproate of potassa remained, and water separated from the alcoholic distillate an aromatic fluid, distilling at from 150° to 160° ; the portion that passed over at 155° had the composition and properties of amyl, $C_{10}H_{11}$, obtained by Frankland in the decomposition of iodide of amyl by zinc.

œnanthylic Acid.—The decomposition of œnanthylic acid ($C_{14}H_{14}O_4$) by the galvanic current was investigated by Brazier and Gossleth with an acid obtained by the action of dilute nitric acid on castor-oil; they found this method tedious, but still preferable to the oxydation of castor-oil or of œnanthole by means of chromic acid. In the electrolysis of an aqueous solution of œnanthylate of potassa, carbonic acid and hydrogen are also given off, whilst an oily liquid of ethereal odour separates. When rectified, the boiling-point of this liquid rose from 130° to 230° and a carbonaceous residue remained. On distilling this liquid with an alcoholic solution of potassa, œnanthylic acid remained with the potassa, and water separated an oil from the alcoholic distillate; when this oil was rectified, its boiling-point rose from 170° to 210° ; the greater portion went over at 202° , and when collected by itself it possessed a boiling-point constant at this temperature and the composition $C_{12}H_{13}$ or $C_{24}H_{26}$. This was *caproyl*; it is not attacked by sulphuric acid nor by distillation with moderately concentrated nitric acid, but is slowly and incompletely oxydized to caproic acid by a mixture of both acids; bromine does not act upon caproyl even in direct solar light; chlorine however does, even in diffused light, with a copious disengagement of hydrochloric acid and formation of a tough substance.—The portion passing over below 202° in the rectification of the above oil, was repeatedly rectified and thus a liquid obtained of an aromatic odour and sweet taste, boiling at 175° , and containing equal equivalents of carbon and hydrogen, most likely $C_{24}H_{24}$.

Pelargonic Acid.—It had formerly been found(1) that oil of rue ($C_{20}H_{20}O_2$) yields by the action of nitric acid, according to the duration of it, besides capric ($C_{20}H_{20}O_4$), also pelargonic ($C_{18}H_{18}O_4$) and caprylic ($C_{16}H_{16}O_4$) acids. Cahours(2) found œnanthylic acid ($C_{14}H_{14}O_4$) to be likewise formed in this reaction, and most likely still lower members of the series of acids $C_nH_nO_4$; by an appropriate duration of the action of commercial nitric acid on oil of rue, any of the above acids may be obtained as the predominant product. Cahours submitted to a closer investigation the pelargonic acid thus formed. In the pure state it is colourless, assuming, however, a yellow tint after some time, boiling constantly at 260° , and then distilling without decomposition or colouration, if the distillation be effected in a current of carbonic acid. The formula, $C_{18}H_{18}O_4$, for the pure acid was con-

(1) Compare Annual Report for 1847 and 1848, II, 41.

(2) Chem. Soc. Qu. J. III, 210.

firmed. Pelargonic acid forms with the alkalies soluble and crystallizable salts, with baryta and strontia salts only slightly soluble in water, soluble in hot alcohol, separating on cooling in the form of crystalline tables of the lustre of mother-of-pearl. Cahours analyzed the baryta- and the lime-salts, the composition of which is $\text{RO}, \text{C}_{16}\text{H}_{17}\text{O}_3$. By passing hydrochloric acid gas into an alcoholic solution of pelargonic acid, washing the yellow oil separating with carbonate of soda and water, drying with chloride of calcium and rectifying, *pelargonate of ethyl*, $\text{C}_4\text{H}_5\text{O}, \text{C}_{19}\text{H}_{17}\text{O}_3$, was obtained in the form of a colourless liquid, which has the spec. grav. 0.86, boils between 216° and 218° , and regenerates alcohol and pelargonic acid when boiled with a concentrated solution of potassa.—Pentachloride of phosphorus (PCl_5) acts violently upon pelargonic acid, hydrochloric acid is given off, and a colourless liquid distils, containing much oxychloride of phosphorus; this being rectified, and that portion removed which passes over before the boiling-point becomes constant, a colourless liquid is at last obtained, heavier than water, and boiling at 220° ; this is *chloride of pelargyl*, $\text{C}_{15}\text{H}_{17}\text{ClO}_2$. It strongly fumes in the air, possesses an intense odour, and forms with alcohol *pelargonate of chloride of ethyl*, with considerable disengagement of heat.—Pelargonate of baryta yields by dry distillation a residue of carbonate of baryta, and a distillate consisting of a brownish oil, solidifying on cooling; the solid mass pressed between bibulous paper and dissolved in ether, separates from this solution by gentle evaporation in the form of large crystalline tables which are *pelargone* ($\text{C}_{17}\text{H}_{17}\text{O}$, or $\text{C}_{14}\text{H}_{13}\text{O}_2$ (isomeric with the aldehyde of margaric acid), they are violently attacked by nitric acid, with formation of a nitro-acid—When exposed to a gentle red heat, with 4 or 5 times its weight of potassa-lime, pelargonic acid yields a considerable quantity of gas, a fluid distillate, and a residue of carbonate. On passing the gas into bromine it forms with it a heavy liquid (hydrogen and another gas, probably marsh-gas, escaping unabsorbed); it has the colour of amber, after the excess of bromine is removed by means of a weak solution of potassa and contains three different compounds: *dibromo-mylene* (probably *dibromo-ethylene*) $\text{C}_4\text{H}_4\text{Br}_2$ (boiling at 130° and crystallizing at 0°), *dibromo-propylene*, $\text{C}_6\text{H}_6\text{O}_3$ (boiling between 143° and 141°), and *dibromo-butylene*, $\text{C}_8\text{H}_8\text{O}_2$ (boiling at 160°); the first, and particularly the third, are present in small quantities. The greater portion of the liquid distillate when rectified passes over between 105° and 110° , the last portion only at 136° . The first portion contains in the mean 84.9 per cent of carbon, and 14.8 per cent of hydrogen; it was free from butyl; and the density of its vapour was found to be 3.98; it is accordingly $\text{C}_{16}\text{H}_{16}$, mixed with some impurities(1); with bromine it evolves heat, forming a liquid of an aromatic odour, $\text{C}_{16}\text{H}_{16}\text{Br}_2$.

(1) The spec. grav. of this liquid is 0.708 at 16° , as Cahours (Compt Rend XXXI, 142;

Acids in
the fat of
the turtle.

Acids in the Fat of the Turtle.—Ch. Linck(1) examined the fat of a turtle. Besides glycerine he found that it contained oleic acid, margaric acid, and a small quantity of the volatile acids of butter, but no stearic acid.

Solid Fatty Acid in Castor-oil.—Saalmüller(2) has examined the solid fatty acid of castor-oil, as a sequel to his former investigations(3). He is of opinion that this acid which was called *margaritic acid* by Bussy and Lecanu, differs (in various sorts of castor-oil) with regard to melting-point and composition, and the results obtained by him differ considerably from those formerly obtained. He has now prepared the acid in question from the deposit, formed in castor-oil, by saponifying it, separating the fatty acids, dissolving them in $\frac{1}{2}$ of alcohol, and cooling the solution for some time below 0° , when the solid acid crystallizes, contaminated with ricinoleic acid and potassa, then pressing and repeatedly crystallizing from alcohol, to which a little hydrochloric acid has been added, in order to free the fatty acid from the tenaciously adhering alkali. In this manner an acid was obtained whose melting-point was 51° , remaining unaltered after repeated crystallizations; this acid crystallizes from its alcoholic solution in white, round masses, sometimes in white tables; its composition is, according to Saalmüller, $2\text{H}_2\text{O}, \text{C}_{60}\text{H}_{57}\text{O}_3$, and that of its salts (the potassa- and the silver-salt were examined; a baryta-salt of a constant composition could not be obtained), $2\text{RO}, \text{C}_{60}\text{H}_{57}\text{O}_3$; the analyses, however, do not agree very well, either among themselves or with the numbers required by these formulae. The ether of this acid was prepared by passing hydrochloric acid gas into its alcoholic solution; it melted at 32° . The acid itself was decomposed when distilled; the

Arch. Ph. Nat. XV, 60) states in another treatise, in which he discusses the decomposition of the acids $\text{C}_n\text{H}_n\text{O}_2$ in general, by being heated with an excess of alkali. He communicates the following facts in addition to those already mentioned on the decomposition of pelargonic acid. Caprylic and cinnathylic acids produce likewise, under these circumstances, fluid hydrocarbons of the composition C_mH_m and the gases C_4H_4 , C_6H_6 , C_8H_8 ; æthalic and margaric acids behave in a like manner. Æthal yields (like hydrated oxide of amyl, see this article), at a temperature approaching to red heat, the same products of decomposition. In all these cases propylene, C_3H_6 , preponderates when compared with C_4H_4 and C_8H_8 . Cahours also draws attention to Hofmann's experiments on valeric acid (p. 269), and arrives at the general result, that the acids $\text{C}_n\text{H}_n\text{O}_2$, starting from the valeric acid, at a temperature necessary for their decomposition by means of an excess of base, do not produce hydrocarbons, C_{n-2}H_n , analogous to marsh-gas, but that these split, during this process, into marsh-gas, hydrogen, and various hydrocarbons C_mH_m , whilst acetic acid, similar to benzoic acid and to the acids homologous with the latter, splits in this decomposition, simply into carbonic acid and hydrocarbons.

(1) Proceedings of the American Association for the Advancement of Science, 2nd Meeting, held at Cambridge, 1849, 384.

(2) Sill. Am. J. [2] VIII, 263.

(3) Annual Report for 1847 and 1848, I, 432.

distillate was yellow, and melted at 54° , and a residue of charcoal remained in the retort.

Chinese
vegetable
tallow.

Chinese Vegetable Tallow.—Borek(1) has investigated the Chinese vegetable tallow which is obtained from the fruits of *Stillingia sebifera*. These fruits contain about 38 per cent kernel, 37 per cent shell, and 25 per cent layer of tallow. Boiling alcohol extracted from the pounded kernels 65 per cent of a mild, fatty, reddish-yellow oil, and from the tallow about 80 per cent of a fat whose melting-point was 40° ; the latter could be raised to 48° by recrystallization. This fat yielded on saponification a fatty acid, of the same composition as the tallow prepared in China.—The latter tallow had a spec. grav. of 0.818, melted at 37° , commenced to solidify at 30° , but became completely hard only at 22° . It readily dissolved in ether, but slightly in cold alcohol; it, however, freely dissolved in 75 parts of boiling alcohol of 0.82 spec. grav., and was deposited again on cooling in the form of a granular mass, with its melting-point unchanged, whilst a liquid fat remained in solution. By saponifying with potassa, precipitating the solution of the soap by means of a solution of chloride of sodium, and decomposing with hydrochloric acid, a crystalline acid was obtained, with the melting-point 55° , which, by repeated crystallizations from alcohol, remained constant between 61° and 62° . A fluid oleic acid remained dissolved in the alcohol; the fluid obtained in the process of saponification contained glycerin. Borek calls the solid fatty acid, *stillistearic acid*; it crystallizes from the alcoholic solution in the form of tables of the lustre of mother-of-pearl, is not changed by being heated from 250° to 300° , and volatilizes at a higher temperature undecomposed; its composition was found to be $C_{30}H_{30}O_4$.—The melting-point of the tallow brought from China could not be raised by recrystallization; the melting-point of the tallow prepared from the shells of the fruits could be raised to 48° by recrystallization from alcohol, and to 60° by recrystallization from ether; the fat with the latter melting-point had the composition $C_{33}H_{31}O_4$, and is regarded by Borek as stillistearin or stillistearate of oxide of lipyl ($C_3H_2O, C_{30}H_{29}O_3$).—The soda-salt of stillistearic acid was obtained in the form of fine crystalline needles; the lead-salt melted at 112° ; its composition agreed with the formula $PbO, C_{30}H_{29}O_3$, whilst that of the silver-salt agreed better with the formula $AgO, C_{32}H_{31}O_3$; the ether-compound melted at 22° , solidified in a crystalline form, and volatilized unchanged at a higher temperature.

Action of over-heated Steam on Fats.—In a paper on the application of over-heated steam, Scharling(2) communicates some state-

(1) J. Pr. Chem. XLIX, 395; Chem. Gaz. 1850, 309. Thomson and Wood's investigation of this substance, see Annual Report for 1849, III, 235.

(2) J. Pr. Chem. L, 375.

Action of
over-heat-
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on fats.

ments on its action on fats. By treating castor-oil with steam, previously passed through a long red-hot tube, twisted in the form of a spiral, a distillate was obtained containing a mixture of fatty acids, which when spread on bibulous paper left scales of the lustre of mother-of-pearl, similar to ricinostearic acid(1). Tallow yielded by a similar treatment a solid crystalline mass, chiefly consisting of margaric acid; this decomposition proceeds, however, but slowly. The formation of acryl-compounds, or pyrelaic or sebacic acid, could not be observed. Spermaceti, dogling-train(2) and wax, suffered a decomposition similar to that produced by strong bases; in the distillate of wax Brodie's cerotic acid(3) was found.

Deportment of Fatty Oils with Bichromate of Potassa and Sulphuric Acid.—Arzbücher(4) has investigated the deportment of some fatty oils when treated with bichromate of potassa and sulphuric acid. Castor-oil and linseed-oil are acted upon by a very dilute mixture; tallow, olein, poppy-seed-oil, stearic acid and margaric acid, only by a concentrated one. The first action, on application of heat, is in most cases violent; vapours of an acid reaction and a strong odour are given off, and drops of oil are floating on the aqueous distillate. In the commencement but little of the acid mixture should be added; when afterwards, during the distillation, just so much water is added as causes the sulphuric acid not to act upon the oil, this is converted into a solid black mass, provided a sufficient quantity of chromic acid has been present. The action on castor-oil and poppy-oil was more closely investigated.—Castor-oil treated in the above manner, with a mixture of 4 parts of bichromate of potassa, 5 sulphuric acid and 2 (?) water, yielded an acid aqueous distillate A, with a supernatant fluid B. The aqueous, strongly-smelling distillate A, was saturated with carbonate of baryta and distilled, when along with the water a neutral oily body, of strong odour, passed over, the remaining baryta-salt was repeatedly crystallized from alcohol, and proved to be œnanthylate of baryta, $\text{BaO}, \text{C}_{14}\text{H}_{13}\text{O}_3$. The oily fluid B contained œnanthylic acid, and the neutral body already mentioned; this latter was isolated by neutralizing the liquid with soda, distilling with water, drying with chloride of calcium and rectifying; it then formed a colourless fluid of an acrid taste and peculiar odour, little soluble in water, but miscible with alcohol in all proportions; its aqueous solution, heated for some time with nitrate of silver to 100° , produced a silver-mirror; it contained 69.3 per cent of carbon, 12.0 hydrogen and 18.7 oxygen, corresponding to the formula of the aldehyde of valeric acid ($\text{C}_{10}\text{H}_{10}\text{O}_2$); when heated with an alcoholic solution of potassa this body was transformed into an acid, the silver-salt of which (obtained in very small quantities) contained

(1) Annual Report for 1847 and 1848, I, 434. (2) Ibid. 437. (3) Ibid. II, 31.
(4) Ann. Ch. Pharm. LXXIII, 199.

from 54.0 to 54.3 per cent of oxide of silver.—Poppy-oil treated in a similar manner with a mixture of 4 parts of bichromate of potassa, 5 sulphuric acid and 6 water, yielded caproic acid and a neutral body, agreeing in its properties with that obtained from castor-oil, and containing 68.5 per cent of carbon, 11.8 hydrogen and 19.7 oxygen.—Castor-oil yields by the decomposition with bichromate of potassa and sulphuric acid more acid products than poppy-oil; olein, as obtained in the manufactures of stearic acid, yields an acid distillate of a different odour, apparently similar to that formed from tallow and rape-oil. Linseed-oil is easiest oxydized, and gives also an acid distillate of a strong odour.

Adipic Acid.—According to a former investigation of Laurent(1), adipic acid, obtained amongst the products of the action of nitric acid on oleic acid, would be, in its so-called hydrated state, $C_6H_8O_4$, in which 1 HO may be replaced by bases. According to C. Bromeis(2), it is $C_{14}H_{11}O_9$; in which 2 HO can be replaced by bases. Laurent(3) now states that, according to a recent investigation of the baryta-salt of this acid, the composition as formerly given by him is the correct one; the formulæ of its salts are: $C_{12}H_8Ag_2O_8$; $C_{12}H_8Ba_2O_8$; $C_{12}H_8Pb_2O_8$; $C_{12}H_8Ca_3O_8 + 4HO$; $C_{12}H_8Sr_2O_8 + 2HO$.

Odmyl.—Laurent(4) proposes new formulæ for the bodies containing mercury and platinum, prepared by Anderson(5), and considered by him as compounds of sulphide of odmyl ($C_8H_8S_2$), as agreeing better with the analyses and the reactions.

Anderson.	Laurent.
$C_{16}H_{16}S_5Hg_1Cl_2$	$C_8H_8CHg_2S_2$
$C_{16}H_{16}S_5Pt_2Cl_2$	$C_8H_8C_2Pt_2S_2$

Uric Acid.—Delffs(6) recommends the following process for the preparation of uric acid from the excrement of serpents: The powdered excrement is heated to boiling with an equal weight of caustic potassa, and 14 times its weight of water; the hot solution is made to flow, immediately from the filter, into a mixture of 2 parts sulphuric acid and 8 water, kept stirred; the uric acid (which is deposited less bulky the hotter the mixture is from which it separates) is decanted and purified by washing.

Products of Decomposition of Uric Acid.—Laurent(7) has proposed new formulæ for several acids derived from uric acid; for

Deport-
ment of
fatty
oils with
bichro-
mate of
potassa
and sul-
phuric
acid.

(1) Ann. Ch. Phys. [2] LXVI, 151; Berzelius' Jahresber. XVIII, 309.

(2) Ann. Ch. Pharm. XXXV, 105; Berzelius' Jahresber. XXI, 309.

(3) Compt. Rend. XXXI, 352.

(4) Compt. Rend. XXXI, 351; J. Pr. Chem. LI, 243.

(5) Annual Report for 1847 and 1848, I, 440.

(6) Pogg. Ann. LXXXI, 311.

(7) Compt. Rend. XXXI, 353; J. Pr. Chem. LI, 244. Wöhler and Liebig's investigation, see Ann. Ch. Pharm. XXVI, 241; Berzelius' Jahresber. XVIII, 558; Schlieper's investigation, see Ann. Ch. Pharm. LV, 251; LVI, 1; Berzelius' Jahresber. XXVI, 874.

Products
of decom-
position
of uric
acid.

mycomelic acid, $C_8H_4N_4O_4$ (the formula of Wöhler and Liebig is $C_8H_5N_4O_5$); for hydriluric acid, $C_{12}H_5N_3O_{10}$, (Schlieper's formula, $C_{12}H_5N_3O_{11}$); for nitro-hydriluric acid, $C_8H_3(NO_4)N_2O_{10}$; according to which it would be nitro-alloxanic acid (Schlieper's formula, $C_8H_3N_3O_{11}$); for diluric acid, $C_8H_5(NO_4)N_2O_8$, (Schlieper's formula, $C_8H_5N_3O_8$, for the hypothetically anhydrous acid).

Schlieper(1) has given the formula $KO, C_6N_2H_4O_6 + H_2O, C_8N_2H_4O_6 + 4 H_2O$ to the air-dried potassa-salt of lantanuric acid, formed by the oxydation of uric acid by means of ferricyanide of potassium and potassa. L. Gmelin(2) pointed out that the data given by Schlieper show an amount of nitrogen different from that which he adopted, and assumes the composition $KO, C_6N_2H_3O_5 + HO, C_6N_2H_3O_5 + 4 H_2O$. Schlieper now(3) acknowledges an error of calculation (which, however, he supposes to have committed in a different place to that in which it really occurred); he corrects, however, at the same time, an error in the manuscript of his former communication, which compensates for the error in calculation, and he adheres, therefore, to his former formula.

L. Gmelin(4) has found that, by passing dry ammonia-gas over finely powdered, dry alloxantin, this substance was moderately reddened at the ordinary temperature; at 100° , it was, however, converted into a deep reddish-brown powder of purpurate of ammonia with disengagement of water.

Hippuric Acid.—Städeler(5) in no instance obtained from the urine of cows benzoic acid, but always hippuric acid, even when the urine was evaporated at a boiling heat, without the addition of lime. The quantity of hippuric acid amounted to nearly 1.5 per cent. A transformation of hippuric acid into benzoic acid appeared in no instance to take place; pure hippuric acid could be boiled for days without suffering decomposition. Städeler thinks that Gregory's(6) method of preparing hippuric acid offers no advantage inasmuch as by boiling the urine with milk of lime, brown resinous substances are formed, which render the purification of the hippuric acid difficult.

In hippuric acid (crystallized from chlorine-water, with which it was treated for the purpose of decolorization), Dauber(7) observed milk-white rhombic crystals, $\infty P \cdot \bar{P} \infty \cdot \bar{P} \infty$. Principal axis : brachydiagonal : macrodiagonal = 1 : 0.9760 : 1.1605; whence, in the brachydiagonal • principal section, $\infty P : \infty P = 99^\circ 52'$, $\bar{P} \infty : \bar{P} \infty = 98^\circ 30'$.—Schabus(8) observed the same combination; he found

(1) Annual Report for 1847 and 1848, I, 447.

(2) Handb. der Chemie, 4. Aufl. V, 140.

(4) Handb. der Chemie, 4. Aufl. V, 319.

(6) Annual Report for 1847 and 1848, I, 450.

(7) Ann. Ch. Pharm. LXXIV, 202.

(3) Ann. Ch. Pharm. LXXIII, 225.

(5) Ann. Ch. Pharm. LXXVII, 18.

(8) Wien. Acad. Ber. July, 1850, 211.

the proportions of the axes = $1 : 0.9742 : 1.1606$, $\infty P : \infty P = 99^\circ 59'$, $\check{P} \infty : \check{P} \infty$ in the brachydiagonal principal section = $98^\circ 30'$, $\bar{P} \infty : \bar{P} \infty$ in the macrodiagonal principal section = $88^\circ 30'$. The crystals may show the appearance of the monoclinometric system by the predominance of one face $\check{P} \infty$ at one end. Tolerable easy cleavage occurs parallel to OP ; spec. grav. = 1.308.—Reinsch(1) mentions a peculiar crystallization of hippuric acid, apparently like octahedrons, obtained by slow evaporation of the solution.

The same chemist observed that yellow hippurate of lime was bleached in a few days by being exposed, whilst moist, to the action of the sun's rays.—Hippurate of lime forms, according to Schabus(2), crystals of the rhombic system, with the faces $\infty \bar{P} \infty$, $\infty \check{P} \infty$, P , $\frac{2}{3} \bar{P} \frac{2}{3}$, $\infty \check{P} \frac{2}{3}$. The crystals assume a foliated form by $\infty \bar{P} \infty$ predominating; the pyramidal faces appear in many cases only on one side of the principal axis. Principal axis : macrodiagonal : brachydiagonal = $1 : 1.9244 : 1.3697$; the terminal edges of P are = $111^\circ 8'$ and $134^\circ 28'$; the lateral edges = $83^\circ 41'$. The crystals possess a perfect cleavage parallel to $\infty \bar{P} \infty$; their spec. grav. is 1.318. Twin crystals are frequently formed, connected by the face $\check{P} \infty$.

H. Schwarz(3) has communicated observations on hippuric acid, and its products of oxydation by means of binoxide of lead.—He accidentally obtained the amorphous modification, first observed by Liebig(4), by recrystallizing hippuric ether (prepared by dissolving hippuric acid in boiling alcohol, saturating the solution with hydrochloric acid gas, and precipitating with water) from very dilute, boiling alcohol, when from the mother-liquor amorphous hippuric acid was deposited in the form of cauliflower-like masses which, after being dried over sulphuric acid, did not lose any more water at 100° , and were $C_{18}H_9NO_6$.—A solution of equal equivalents of benzoic and hippuric acids, saturated with baryta-water, deposits on evaporation, first benzoate of baryta, then hippurate of baryta, and at last a double salt of benzoate and hippurate of baryta, in the form of dull-looking masses, which are, when dried over sulphuric acid, BaO , $C_{11}H_5O_3 + BaO$, $C_{18}H_9NO_5 + 5 H_2O$ (4 H_2O escape at 100°).—On decomposing hippuric acid by binoxide of lead, Schwarz found the statements of Fehling(5) on this subject completely verified. He remarks concerning the benzamide ($C_{11}H_7NO_2$) hereby formed, that it crystallizes very beautifully and pure from a weak ammoniacal solution or from very dilute potassa, and that it is completely decomposed into benzoic acid and ammonia only by very concentrated potassa, or by very

(1) Jahrb. Pr. Pharm. XX, 217.

(2) Wien. Acad. Ber. July, 1850, 215.

(3) Ann. Ch. Pharm. LXXV, 190; Chem. Gaz. 1850, 469 (in abstr.)

(4) Ann. Ch. Pharm. LXV, 351.

(5) Ibid. XXVIII, 48.

protracted boiling with concentrated hydrochloric acid.—When crude benzamide, prepared according to Fehling's direction, by decomposing hippuric acid with binocide of lead, is crystallized from hot water, a silky, crystalline mass, nearly insoluble in hot water, is left behind, especially when, in the decomposition of the hippurate of lead by means of sulphuric acid, the latter has been used in excess. This mass was soluble in hot alcohol, from which it separated again on cooling, in the form of fine silky needles. On decomposing hippuric acid by a considerable amount of binocide of lead, and a large quantity of sulphuric acid, and applying a gentle heat, a copious disengagement of carbonic acid ensues, and the whole mass becomes solid in consequence of the formation of these silky needles (phosphoric and nitric acids act like sulphuric acid). The mass was washed with hot water, and the residue boiled with alcohol, when the needles united into bunches separated from the alcoholic solution; they were dried over sulphuric acid between bibulous-paper, boiled with water, and washed. The substance thus obtained, termed by Schwarz *Hipparaffin*, has the composition $C_{16}H_8NO_2$, and is formed, according to him, by the elimination from the hippuric acid ($C_{18}H_8NO_3$) of C_2O , which is farther oxydized to carbonic acid. *Hipparaffin* melts at about 200° , and solidifies into a crystalline mass; when heated more strongly, it partly distils unchanged, a dark residue being left behind; it burns in the air with a luminous, sooty flame. It is very little soluble in water, and as little in ammonia, dilute hydrochloric and sulphuric acids, but easily in ether, from its solution in an alcoholic solution of potassa, it is precipitated by water, and when fused with hydrated potassa it disengages ammonia. Concentrated sulphuric and nitric acids dissolve it without change, and water separates it again from the solution; fuming nitric acid decomposes it, especially when heated; it is not changed by bichromate of potassa and sulphuric acid, nor by chlorate of potassa and hydrochloric acid.

Amides, Amidogen-Acids and Collateral Matter. Oxamide.—Reinar(1) opposes the assumption of amidogen as a proximate constituent of oxamide ($C_2O_2NH_2$), because concentrated sulphuric acid dissolves oxamide (in the cold) without change. He found that, by moderately heating oxamide with potassium, cyanide of potassium is formed, and he considers that cyanogen is contained in oxamide ready formed; he writes, therefore, its formula $C_2N + 2HO$. He observes that the nitriles of Kolbe and Frankland(2) are considered as

(1) Arch. Pharm. [2] LXII, 305.

(2) Annual Report for 1847 and 1848, I, 456.

cyanogen-compounds, and he thinks that the amides have a similar constitution; acetamide is oxamide + C_2H_3 , propionamide, oxamide + C_4H_5 , &c.

Asparagin.—Pasteur(1) found, in contradiction to Piria's(2), statements, that green vetch plants, grown in the light, yield no asparagin, whilst he obtained 5 to 6 grms. of asparagin from 1 litre of the juice of such plants as had grown in a cellar. Pasteur's crystallographic description of asparagin agrees with that of Bernhardt(3); also, according to him, its crystalline form belongs to the rhombic system, and shows $\infty P . 0 P . m \bar{P} \infty . \infty \bar{P} \infty$ with $\frac{P}{2}$ ($\infty P : \infty P = 129^\circ 37'$; $\frac{P}{2} : 0 P = 116^\circ 57'$; $m \bar{P} \infty : 0 P = 120^\circ 46'$); so that, when the prism is placed in such a manner that the obtuse angle is in front, a face of $\frac{P}{2}$ appears in front at the upper part to the left. According to Bernhardt's description, the opposite rhombic sphenoid was observed, with a face in front to the right, at the upper part, when the prism occupied the same position(4).

Aspartic Acid.—According to Dessaignes'(5) statement, asparagin, in the fermentation induced by cascine, is first converted into aspartate and then into succinate of ammonia. On heating asparagin to 200° , until no farther odour of ammonia is observed, a brown, slightly soluble substance is left, yielding, when treated with hydrochloric acid, aspartic acid, which crystallizes in short, hard prisms. This form is not exhibited by aspartic acid, when prepared in the usual manner, and occurs also with aspartic acid prepared from malic, maleic, or fumaric acids, in the manner above described (p. 256).—Dessaignes(6) gives the following details respecting the formation of aspartic acid from bimalate of ammonia. Pursuing Piria's views on the relations between aspartic and malic acids (Annual Report for 1847 and 1848, II, p. 114), he was induced to attempt the preparation of aspartic acid from bimalate of ammonia. On heating this salt in an oil-bath from 160° to 200° , it swells up, whilst water, containing very little ammonia, volatilizes, and a reddish, resinous residue, only slightly soluble in boiling water, is left behind. By repeatedly washing with hot water, an amorphous, pale, brick-

(1) Ann. Ch. Phys. [3] XXXI, 70.

(2) Annual Report for 1847 and 1848, II, 114.

(3) Ann. Ch. Pharm. XII, 58.

(4) If the crystal be developed on one end only, the faces occurring may simply be referred to a monoclinometric combination. The statement (H. Kopp's Krystallographie, 312) that asparagin crystallizes in the monoclinometric system, originates from the examination of such crystals. On assuming these crystals to belong to the rhombic system, the hemihedral faces appear in the manner stated by Pasteur.

(5) Loc. cit. p. 256.

(6) Compt. Rend. XXX, 324; Instit. 1850, 92; J. Pharm. [3] XVII, 349; Laur. and Gerh. C. R. 1850, 162; J. Pr. Chem. L. 289.

Aspartic
acid.

coloured powder, of an earthy taste, is obtained, which is a new nitrogenous acid, differing from aspartic acid, soluble in hot concentrated acids, and separated again, unchanged, from those solutions by water. This substance, however, is transformed, when heated for from five to six hours with nitric or hydrochloric acids; addition of water then produces no longer a precipitation. On evaporation, a brown, crystalline, very acid residue is left, which (when hydrochloric acid has been used) is a compound of hydrochloric acid with an organic substance, and may be obtained in colourless crystals, if treated with charcoal. This compound was dissolved in a considerable quantity of hot water, one half of the substance carefully neutralized with ammonia, and the other half added, when aspartic acid crystallized on cooling, in the form of the above-mentioned short prisms. The acid thus crystallized has the same composition as the common aspartic acid, and the salts of both possess similar form and composition.—Dessaigues has not communicated the analytical proofs of his statements.—J. Wolff(1) has confirmed Dessaigues' statements, by repeating these experiments with bimaleate of ammonia. Wolff found the body—which boiling water extracts from the residue of the heated ammonia-salt, and which separates on the cooling of the washing water, or immediately when acids are added to it—to contain 50.1 per cent of carbon, 4.1 of hydrogen, 12.2 of nitrogen, 33.6 of oxygen, approximately corresponding to the formula $C_8H_3NO_4$, whence, on heating bimaleate of ammonia, a larger quantity of water escapes than is requisite for the formation of aspartic acid. He observed that, on boiling the above residue with nitric acid, a chemical combination of aspartic acid with nitric acid is also formed, which may be obtained crystallized by a careful expulsion, in the water-bath, of the excess of nitric acid. From the solution of this compound, aspartic acid may be obtained, either after the method of Dessaigues or by neutralizing it with lime, precipitating the aspartate of lime with alcohol, and decomposing the lime-salts by means of oxalic acid. The composition of the aspartic acid thus obtained, air-dried, corresponded to the formula $C_8H_7NO_8$; the amount of baryta in the baryta-salts, dried at 120° , to the formula $BaO, C_8H_6NO_7$; the amount of silver of the silver-salt, dried at 100° , to the formula $2AgO, C_8H_5NO_6$.

Ethamine-Sulphuric Acid.—Strecker(2) has discovered a new conjugate sulphuric acid, which he calls *Ethamine-sulphuric acid*. The ammonia-salt of this acid is obtained in foliated crystals, when dry ammoniacal gas is passed into neutral sulphate of oxide of ethyl (obtained, according to Wetherill(3), from anhydrous sul-

(1) Ann. Ch. Pharm. LXXV, 293.

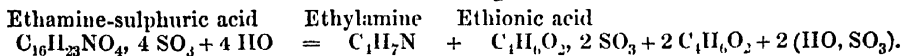
(2) Ann. Ch. Pharm. LXXV, 46; Compt. Rend. XXXI, 206.

(3) Annual Report for 1847 and 1848, II, 20.

phuric acid and ether); and the alcoholic or aqueous solution of the product, at first liquid, is evaporated over sulphuric acid. This salt deliquesces in moist air, is soluble in alcohol, but not in ether; it melts readily below 100° , and burns, when strongly heated, with a feeble luminous flame, and the odour of sulphide of ethyl. Its solutions possess an insipid taste; they do not act upon vegetable colours, and are not precipitated by metallic salts. Potassa, soda and baryta disengage from it, even whilst cold, ammonia, with formation of the ethamine-sulphate of the base added. With nitric acid and chloride of barium, a precipitate of sulphate of baryta is formed, but only after protracted boiling; this is more readily and completely effected by evaporating with an excess of baryta-water. The analysis of the ammonia-salt, dried over sulphuric acid, led to the formula $C_{16}H_{23}NO_4, 4 SO_3 + NH_3$, whence its formation may be explained by the equation $4 (C_4H_5O, SO_3) + 2 NH_3 = C_{16}H_{23}NO_4, 4 SO_3 + NH_3$. Bichloride of platinum precipitates only one half of its nitrogen in the form of ammonio-chloride of platinum, the other half of the nitrogen is contained in the acid. On evaporating in the water-bath an alcoholic solution, containing bichloride of platinum in excess, brilliant golden tables of chloride of platinum and ethylamine are gradually deposited. On heating the moist ammonia-salt to 100° , it becomes acid, and then contains free sulphuric acid. Ethamino-sulphate of lead is obtained in needle-shaped crystals, by boiling the ammonia-salt with protoxide of lead, and evaporating the solution, after being freed from the excess of protoxide of lead by means of carbonic acid. The free acid, prepared by decomposing the lead-salt with sulphuretted hydrogen, is decomposed on boiling; sulphuric acid being set free. The baryta-salt is easily soluble, and crystallizes with difficulty.

Ethamine-sulphuric acid.

On being heated with acids, ethamine-sulphuric acid splits into ethylamine, free sulphuric acid and other products, not farther investigated by Strecker, amongst which, in addition to alcohol, ethionic acid might occur, according to the equation:



When the acid is boiled with potassa, ethylamine is formed, which distils over.

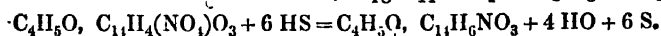
Nitrophtalimide.—On adding, according to Laurent(1), a little nitric acid to nitrophtalate of ammonia an acid salt is precipitated, containing $NH_3 + C_{16}H_5(NO_4)O_8 + 4 HO$; this salt loses water when heated to incipient fusion, and is thus converted into nitrophtalimide, $C_{16}H_4(NO_4)NO_4$.

Sulphanilic Acid.—On successively treating benzol with nitric acid, sulphuretted hydrogen and sulphuric acid, sulphanilic acid is formed.

Carbanillic
acid.

This acid may also be prepared, according to Laurent(1), in the following manner. Sulphobenzolic acid is boiled with nitric acid, when *nitrosulphobenzolic acid* is formed, the ammonia-salt of which contains, $\text{NH}_3 + \text{C}_{12}\text{H}_5(\text{NO}_4), 2 \text{SO}_3$, and yields, on being treated with sulphuretted hydrogen, sulphanilate of ammonia.

Carbanillic Acid.—Chancel(2) has communicated the following researches on the carbanilates of oxide of ethyl, and of oxide of methyl. Just as nitrobenzamide is converted into carbanilamide(3), under the influence of sulphuretted hydrogen, or sulphide of ammonium, so is nitrobenzoate of oxide of ethyl converted into carbanilate of oxide of ethyl under the same circumstances, $\text{C}_{18}\text{H}_{11}\text{NO}_4 = \text{C}_4\text{H}_5\text{O}, \text{C}_{14}\text{H}_6\text{NO}_3$:



The same difference of composition exists between carbanilate of oxide of ethyl and urethane, as between aniline and ammonia; Chancel designates carbanilate of oxide of ethyl as *carbanilethane*. In order to prepare it, nitrobenzoate of ethyl is dissolved in alcohol, and a small quantity of sulphide of ammonium added; sulphur is precipitated, and after the action is completed (which soon occurs on the application of a moderate heat) the carbanilate of oxide of ethyl is precipitated by water in the form of a heavy, almost colourless oil, which is purified by repeatedly dissolving it in alcohol, and afterwards precipitating with water. The alcoholic solution yields, on being treated with potassa, carbanilate of potassa and alcohol, and with ammonia, carbanilamide and alcohol.—Carbanilate of methyl, $\text{C}_{16}\text{H}_9\text{NO}_4 = \text{C}_2\text{H}_3\text{O}, \text{C}_{14}\text{H}_6\text{NO}_3$ (*carbanimethylane*), prepared in a like manner from nitrobenzoate of oxide of methyl, is also an oily fluid of greater spec. grav. than water, and its deportment entirely corresponds to that of carbanilate of ethyl.

Organic Bases. Quinine.—Ch. Linck(4) has found that the *sulphate of quinine* of commerce possesses the formula $2 \text{C}_{20}\text{H}_{12}\text{NO}_2, \text{HO}, \text{SO}_3 + 4 \text{HO}$ (9.8 per cent of sulphuric acid, and 8.4 per cent of water of crystallization;) the 4 equivs. HO escape at 130° . He is of opinion that the purity of the commercial article may be judged by simply determining the amount of sulphuric acid. This, however, is not quite correct; for, abstracting from the circumstance that the most frequent adulteration of the officinal quinine salt consists in an admixture of sulphate of cinchonine, there exist—as shown by the

(1) Compt. Rend. XXXI, 538; J. Pr. Chem. LII, 59.

(2) Compt. Rend. XXX, 751; Instit. 1850, 186. Preliminary notice, Annual Report for 1849, III, 245.

(3) Annual Report for 1849, III, 245.

(4) Proceedings of the American Association, 2nd meeting, held at Cambridge, 1849, 275.

experiments of Baup and Van Heijningen(1)—compounds of sulphuric acid and quinine with different amounts of water.

G. W. Elderhorst(2) has prepared a series of salts of organic bases not hitherto known, and has partly subjected them to analysis; the results obtained by him are given under the individual bases.—A solution of quinine in hydrofluoric acid is converted, but only on evaporation, into a mass of fine, deliquescent needles, concentrically arranged (*hydrofluorate of quinine*), which are very readily soluble in alcohol.—*Urate of quinine* cannot be obtained in a crystalline form; the aqueous solution obtained by boiling an excess of quinine with uric acid dries up into a white, foliated, amorphous mass.—*Cyanurate of quinine* is white, amorphous, not crystallizable from either water or alcohol.

Organic
Bases
Quinine.

On treating, according to F. L. Winckler(3), a solution of 1 equiv. of hydrochlorate of quinine with 4 equivs. of iodide of potassium, a resinous compound, persistent in the air, is obtained, which, as Winckler supposes, does not consist of iodine and quinine, but is *hydriodate of quinine*. Winckler found in it 28.4 per cent of iodine. The formula $2C_{20}H_{12}NO_2, HI$ requires 28.1 per cent.

Quinoidine.—R. Lehmann(4) examined several kinds of quinoidine, which were adulterated to the amount of $\frac{1}{4}$ their weight with the sulphates of potassa, soda and lime, and with copper, &c.—Volland(5) found in one sample upwards of 13, Overbeck(6) from 20 to 40, and Wessel(7) 61 per cent of colophony; Walpert(8) found quinoidine adulterated with 7.5 per cent of the carbonates of lime and magnesia, &c.

Cinchonine.—Hlasiwetz(9) has made a new investigation regarding the composition of cinchonine. He found that commercial cinchonine usually contained, in addition to a brown basic resin, a certain amount of that modification of quinine (β quinine $C_{20}H_{12}NO_2$), which Van Heijningen(10) has shown to be a constituent of quinoidine. Hlasiwetz proposed to call it *cinchotine*. Pure cinchonine is obtained by *fractional* crystallization from alcohol when it is first deposited, whilst cinchotine remains in the mother-liquor. Cinchonine crystallizes in moderately large, brilliant prisms, pretty easily soluble in alcohol; when heated by itself it partially sublimes in woolly crystals; in a current of hydrogen, or ammoniacal gas,

(1) Annual Report for 1849, III, 255.

(2) Ann Ch Pharm LXXIV, 77, Chem. Gaz 1850, 327

(3) Jahrb. Pr Pharm XX, 321.

(4) Arch. Pharm [2] LXI, 132.

(5) Arch Pharm [2] LXI, 136.

(6) Ibid 304.

(7) Ibid. 306.

(8) Ibid 308.

(9) Wien Acad. Ber. January, 1850, 9, March, 267, Ann. Ch. Pharm. LXXVII, 49; J. Pr. Chem LI, 409

(10) Annual Report for 1849, III, 255.

Cincho-
nine.

brilliant prisms, upwards of an inch in length, are obtained. Cinchotine is deposited from the alcoholic mother-liquor, and especially from ether—in which it is very soluble—in the form of very large rhomboidal crystals of diamond lustre, which melt, on heating, into an opaque amorphous mass, and are not sublimable either by themselves, or in a current of hydrogen or ammonia.

Hlasiwetz confirms the formula $C_{20}H_{12}NO$, or perhaps more correctly $C_{40}H_{23}N_2O_2$, for pure cinchonine. Ten ultimate analyses yielded numbers in which the carbon varied only between 77.78 and 78.24 per cent., the hydrogen between 7.65 and 7.80 per cent. The former formula requires 77.92 per cent of carbon and 7.79 per cent of hydrogen, the latter 78.18 and 7.49. A platinum double-salt, corresponding to these formulæ, is obtained only when the light yellow precipitate formed at first (giving numbers corresponding to Laurent's formula) is dissolved in water by protracted boiling, when, on cooling, the pure compound is deposited in the form of a whitish pulverulent precipitate. By oxydizing agents, such as chlorine, nitric acid, terechloride of phosphorus, acid bichloride of platinum, permanganate of potassa, binoxide of manganese and sulphuric acid, as well as by emulsin in a state of fermentation, cinchonine suffers no change, according to the experiments of Hlasiwetz.

A solution of newly precipitated cinchonine in dilute hydrofluoric acid yields, according to Elderhorst(1), on evaporation *hydrofluorate of cinchonine* in colourless prisms, belonging to the trimetric system; they are four-sided prisms, with a rhomboidal transverse section, and pointed by four-sided pyramids. When heated to 100° they become milk-white, and at a higher heat, previous to decomposition, purple. The analysis nearly corresponds to the formula $C_{20}H_{12}NO, HFl$. This salt also crystallizes from dilute alcohol.—By mixing sulphate of cinchonine with a cold solution of bichromate of potassa, *chromate of cinchonine* is obtained, in the form of a yellow, amorphous precipitate, and after having been left standing for some time also in prismatic crystals. This compound melts, when heated in water and alcohol, into a tough yellowish-brown mass.—On heating to boiling, for some time, uric acid and an excess of newly precipitated cinchonine, with a considerable quantity of water, and filtering whilst hot, *urate of cinchonine* crystallizes in prisms of $\frac{1}{3}$ to $\frac{1}{4}$ of an inch in length, amongst which many twin crystals, like harmotome, may be observed. This salt is soluble with difficulty in water, alcohol and ether. On drying, the crystals become opaque, and disintegrate into a powder which is at first white, then of a beautiful sulphur colour, whilst in the crystals a continuous motion ensues, visible under the microscope, and in larger masses to the naked eye. The crystals are thus transformed into innumerable little crystals, probably of another form.

(1) Loc. cit. p. 285.

The salt, when dried in the air, is composed according to the formula $C_{20}H_{12}NO, HO + C_5HN_2O_2 + 4HO$; it loses the 4 equivs. of HO (12.49 per cent calculated, 13.73 per cent found) at 100° .—A solution of parabanic acid, saturated with an excess of cinchonine at a boiling heat, dries up into a yellowish transparent mass of *oxalurate of cinchonine*, which gradually becomes white and crystalline. Hydrochloric acid separates from it pulverulent oxaluric acid, which dissolves on boiling, with formation of oxalic acid.—On dissolving newly precipitated cinchonine in a saturated, boiling solution of cyanuric acid, *cyanurate of cinchonine* crystallizes in flat, four-sided, oblique prisms, soluble with difficulty in water, insoluble in alcohol and ether. They contain cyanuric acid and cinchonine, and lose at 100° 17.79 per cent of water; heated beyond 200° they are decomposed.—*Hippurate of cinchonine* is not crystallizable; its solution gradually solidifies into an amorphous, compact, transparent mass.

Quinidine—Winckler(1) describes a bark given to him by Zimmer, and obtained from London, under the name of "Quina of Maracaibo;" it contains, according to his investigation, quinovate of quinidine, along with a peculiar yellow colouring matter, not changed by sesquichloride of iron, a considerable quantity of quinate of lime, a very small amount of quimo-tannic acid, and no quinaried.

Morphine—Bley(2) has shown that animal-charcoal cannot be used for examining opium in reference to its amount of morphine, inasmuch as 5 ozs. of the charcoal were necessary in order to precipitate all the basis from 1 oz. of opium, and the large quantity of alcohol required, extracted a very highly coloured salt of the basis.

According to Th. Wertheim(3) morphine yields, with hydrated potassa, at 200° a distillate which contains methylamine, C_2H_5N .

A solution of 120 parts of acetate of morphine, mixed with 60 parts of iodide of potassium yields, according to Winckler(4), *hydriodate of morphine* (by Winckler considered as iodide of morphine), in the form of brilliant, four-sided prisms, similar to sulphate of quinine. This salt contains, according to his analysis, 28.6 per cent of iodine. The formula $C_{11}H_{19}NO_6, HI$ requires 30.7 per cent of iodine; the same, with 3 equivs. of water, 28.8 per cent.

Hydrofluorate of morphine crystallizes, according to Elderhorst(5), in colourless, four-sided prisms, one inch in length, only slightly soluble in water, and insoluble in alcohol and ether.—On heating uric acid with morphine to boiling, and filtering whilst hot, *urate of morphine* crystallizes in short, brownish prisms, concentri-

(1) Rept. Pharm. [3] V, 194.

(2) Arch. Pharm. [2] LXII, 162.

(3) Wien. Acad. Ber. January, 1850, 33, Ann. Ch. Pharm. LXXIII, 210; Chem. Gaz. 1850, 142

(4) Loc. cit. p. 285

(5) Ibid. p. 285.

Codeine. cally grouped, which cannot be recrystallized without undergoing decomposition.—*Cyanurate of morphine* forms colourless, narrow, concentrically grouped prisms, $\frac{1}{2}$ inch in length, which, on being recrystallized, are transformed into a white, amorphous mass. It contains always crystals of free cyanuric acid, even when an excess of basis has been used.—*Hippurate of morphine* does not appear to be crystallizable. A solution of morphine in hippuric acid solidifies, on evaporation to dryness, into a solid, transparent, amorphous mass.

Codeine.—Th. Anderson(1) has established the formula of codeine by an extensive and elaborate investigation of this base and some of its derivatives. It is $C_{36}H_{21}NO_6$, and codeine contains therefore C_2H_2 more than morphine, $C_{34}H_{19}NO_6$. Anderson's analyses, and the former analyses of other chemists (recalculated for the atomic weight of carbon now adopted), give for the composition of anhydrous codeine:

	Anderson.				Regnault.		Gregory.	Will.	Cotterbe.	Calc.
										$C_{36}H_{21}NO_6$
C	71.91	72.02	72.09	72.09	73.31	72.93	73.18	73.27	72.10	72.24
H	7.05	7.04	7.14	7.16	7.19	7.23	7.23	7.25	7.17	7.02
N	4.41	4.60	4.50	"	4.89	4.89	4.82	"	"	4.68
O	16.63	16.34	16.27	"	14.61	14.95	14.77	"	"	16.06

Codeine crystallized from water or aqueous ether contains 2 equivs. of water = 5.67 (found 5.66) per cent. It crystallizes, according to W. H. Miller's determination, in the rhombic system; when crystallized from alcohol in the combinations $\infty P \cdot OP \cdot \bar{P} \infty \cdot \bar{P} \infty$, and in $\infty P \cdot \bar{P} \infty \cdot \frac{1}{2} \bar{P} \infty$ when crystallized from water.— $\infty P : \infty P = 87^\circ 40'$; $\bar{P} \infty : OP = 141^\circ 37'$; $\bar{P} \infty : OP = 140^\circ 23'$; $\frac{1}{2} \bar{P} \infty : OP = 157^\circ 25'$; cleavage parallel to OP . It is a powerful base which renders reddened litmus blue and precipitates the oxides of lead, copper, iron, cobalt, nickel and other metals from their solution; it is precipitated from its salts by potassa; in every instance, however, a certain quantity of codeine remains in solution, even when a considerable excess of alkali has been used; ammonia also precipitates codeine, but only slowly, and in small transparent crystals; it is not more soluble in concentrated ammonia than in water, 1 part requiring 68 parts. With regard to the preparation of codeine, Anderson mentions, that it is advantageous to evaporate first the mother-liquor, after precipitating the morphine by ammonia, (whereby the greater part of the chloride of ammonium remains in solution), to recrystallize the crystals thus obtained, and then to decompose with potassa. Codeine is separated in the form of an oil gradually becoming solid and crystalline, of which more is obtained on evaporation; ultimately morphine crystallizes from the alkaline mother-liquor in

(1) Edinb. Trans. XX, Part I, 57; Chem. Gaz. 1851, 41, 68; Ann. Ch. Pharm. LXXVII, 341; Laur. and Gerh. C. R. 1850, 321.

the form of silky needles, which morphine, however, did not exist in the solution as a double salt with codeine, as was formerly supposed, because by successive crystallizations hydrochlorate of codeine, free from morphine, may be obtained from the mother-liquor containing sal-ammoniac.—The codeine precipitated by potassa is purified by redissolving in hydrochloric acid, boiling with animal charcoal, precipitating by potassa slightly in excess, and redissolving in ether containing water, but being free from alcohol.

Hydrochlorate of codeine, $C_{36}H_{21}NO_6$, $HCl + 4 HO$, is deposited from the hydrochloric solution of the base in the form of short, star-like grouped needles, which appear under the microscope as four-sided prisms with 2 edges bevelled. It dissolves in 20 parts of water at 33° , and in less than its own weight of water at 100° . The salt, with 4 equivs. HO , dried in the air, loses 1 equiv. of HO at 100° and the other 3 equivs. at 250° with a portion of the acid.—*Hydroiodate of codeine*, $C_{36}H_{21}NO_6$, $HJ + 2 HO$ (at 100°) crystallizes in long slender needles, soluble in about 60 parts of cold, but much more readily in hot water.—*Sulphate of codeine*, $C_{36}H_{21}NO_6$, HO , $SO_3 + 5 HO$, crystallizes in radiated, long needles, or by spontaneous evaporation in flat, four-sided prisms (according to W. H. Miller's determination in the rhombic combination $\infty P \cdot \check{P} \infty \cdot \infty \check{P} \infty$, where $\infty P : \infty P = 151^\circ 12'$, $\infty \check{P} \infty : \check{P} \infty = 113^\circ 45'$, $\check{P} \infty : \check{P} \infty = 133^\circ 30'$, $\infty \check{P} \infty : \infty P = 104^\circ 24'$, cleavage parallel to $\infty \check{P} \infty$), soluble in 30 parts of cold, more readily in hot water.—*Nitrate of codeine*, $C_{36}H_{21}NO_6$, HO , NO_5 , is obtained when nitric acid of 1.060 spec. grav. is added to powdered codeine, an excess of acid being carefully avoided; it is readily soluble in hot water, and is deposited from it in the form of small prismatic crystals.—*Phosphate of codeine*, $C_{36}H_{21}NO_6$, HO , $2HO$, $PO_5 + 3 HO$, is precipitated by alcohol as a crystalline powder from a concentrated solution of codeine in phosphoric acid.—*Oxalate of codeine*, $C_{36}H_{21}NO_6$, HO , $C_2O_3 + 3 HO$, crystallizes in short prisms, soluble in 30 parts of water, at 33° , in $\frac{1}{2}$ part at 100° .—*Hydrosulphocyanate of codeine*, $C_{36}H_{21}NO_6$, $HC_2NS_2 + HO$, separates in the form of radiated needles on adding sulphocyanide of potassium to hydrochlorate of codeine.—*Bichloride of platinum and codeine*, $C_{36}H_{21}NO_6$, HCl , $PtCl_2 + 4 HO$, is a pale yellow, pulverulent precipitate, gradually becoming darker and crystalline, soluble in hot water, with partial decomposition, especially when an excess of bichloride of platinum is present. The salt, when air-dried, loses at 100° 3 equivs. of water, the fourth at 121° , with partial decomposition.—Codeine gives with protochloride of mercury a white, crystalline compound, soluble in boiling water and in alcohol, and with chloride of palladium a yellow precipitate; chromate of codeine forms yellow needles; hydrocyanate and tartrate of codeine are not crystallizable.

Amor-
phous
codeine.

Amorphous Codeine.—A solution of codeine in an excess of moderately concentrated sulphuric acid becomes dark when heated for some time, and yields then with carbonate of soda a grey precipitate of amorphous codeine, which is not the case with salts of codeine. After being washed with water, dissolved in alcohol and reprecipitated by water, a greyish-green powder is obtained which is insoluble in water, but readily soluble in alcohol and from which it is again precipitated by ether. At 100° it melts into a resinous mass. It forms amorphous salts with acids. By a continued action of sulphuric acid on codeine, a dark-green compound is formed which contains sulphur, and corresponds to sulpho-morphide or sulpho-narcotide.

Nitro-codeine.—By the action of strong nitric acid on codeine, a yellow, resinous acid, soluble in alcoholic fluids with a red colour, is formed, which has as yet not been farther investigated by Anderson. When, however, finely-powdered codeine is put into nitric acid of 1.060 spec. grav. and heated, but not to boiling, until a precipitate is produced by ammonia, which precipitate does not increase in successive trials, the liquid holds in solution a nitro-base, *nitro-codeine*, precipitable on neutralization with ammonia in the form of silvery, slightly yellow laminæ. In this operation, which lasts only a few minutes, none of the red vapours always accompanying the formation of the resinous acid are given off. Nitro-codeine is purified by dissolving it in hydrochloric acid, boiling with animal charcoal, precipitating with ammonia, and recrystallizing from weak alcohol or from alcohol and ether. It is with difficulty soluble in hot water and in ether, but readily in boiling alcohol; the solutions of its salts are neutral; potassa and ammonia precipitate the base in the form of a crystalline powder. The analysis led to the formula $C_{36}H_{20}(NO_4)NO_6$.—*Hydrochlorate of nitro-codeine* is not crystallizable; the *sulphate*, $C_{36}H_{20}(NO_4)NO_6 \cdot HO \cdot SO_3$, is readily soluble in hot water, and crystallizes in short, radiated needles, the *oxalate* in yellow, short prisms. The *platinum-salt*, insoluble in water and alcohol, is $C_{36}H_{20}(NO_4)NO_6 \cdot HCl \cdot PtCl_2 + 4 HO$.—On heating an alcoholic solution of nitro-codeine with sulphide of ammonium, sulphur is deposited, and the dark liquid yields then, with ammonia, a brown amorphous precipitate of a new base, having a different deportment from that of nitro-codeine. Anderson supposes it to be $C_{36}H_{22}N_2O_6$.

Bromo-codeine.—Finely-powdered codeine dissolves in bromine-water, when gradually added, with a peculiar red colour; ammonia precipitates from the solution *bromo-codeine*, containing codeine, in the form of a white powder, scarcely soluble in cold water, and which is purified by dissolving it in hydrochloric acid, reprecipitating with ammonia and recrystallizing from alcohol mixed with its own bulk of water. The base is scarcely soluble in ether, and

when dried at 100° has the formula $C_{36}H_{20}BrNO_6$; under circumstances not as yet ascertained, it takes up sometimes 1 equiv. of HO (2.32 per cent), sometimes 3 equivs. (6.66 per cent).—*Hydrochlorate of bromo-codeine* crystallizes in radiated needles; the hydrobromate, $C_{36}H_{20}BrNO_6$, $HBr + 2 HO$, in small prisms, readily soluble in hot water; the platinum-salt, $C_{36}H_{20}BrNO_6$, HCl , $PtCl_2$, is a pale yellow powder, insoluble in water and in alcohol.

Tribromo-codeine.—By the continued action of an excess of bromine-water on bromo-codeine a pale yellow, at last constant precipitate of hydrobromate of *tribromo-codeine* is formed, from which the base is separated by washing with water, dissolving in dilute hydrochloric acid and precipitating with ammonia. By adding water to its alcoholic solution, it is obtained as an amorphous powder; this is grey when dried, insoluble in water and ether, but readily soluble in alcohol. On being dissolved in hot hydrochloric acid, it appears to undergo partial decomposition. The analysis of tribromo-codeine leads to the formula $C_{36}H_{18}Br_3NO_6$. The salts of this very feeble base are all very slightly soluble in water and are amorphous. For the hydrobromate of tribromo-codeine, as it is formed when preparing this base, Anderson found the formula $2 (C_{36}H_{18}Br_3NO_6) + 3 HBr$; the platinum-salt, $C_{36}H_{18}Br_3NO_6$, HCl , $PtCl_2$, is a brownish-yellow powder, soluble in water and alcohol.

Chloro-codeine.—On treating an aqueous solution of codeine with chlorine, a deep brown, almost black fluid is obtained, from which ammonia precipitates an amorphous, resinous base. The preparation of chloro-codeine succeeds better on application of chlorate of potassa. To a solution of codeine in an excess of dilute hydrochloric acid, heated to 60° or 70° , chlorate of potassa is gradually added, until a precipitate is produced in the solution by ammonia, when on adding an excess of ammonia *chloro-codeine* is precipitated in the form of a crystalline, generally somewhat yellow powder. It is purified like bromo-codeine, which it resembles in every respect. Anderson found the formula of the crystallized base to be $C_{36}H_{20}ClNO_6 + 3 HO$. The sulphate contains 4 equivs of water of crystallization(1).

(1) A compound of iodine and codeine is obtained, according to Anderson (Edinb. New Philos. Journ. L, 103), by dissolving equal weights of iodine and codeine in the least possible quantity of alcohol and allowing it to stand, when this fine compound is deposited in the form of small crystals; these are beautifully ruby-coloured in transmitted light, and in reflected light deep violet, and possess a lustre like diamond, which is almost metallic in strong light (Haidinger's description of the triclinometric form and the optical deportment of these crystals, for which he proposes the name of *Andersonite*, see Pogg. Ann. LXXX, 553). This compound is insoluble in water and in ether, but soluble in alcohol, with a reddish-brown colour; it is dissolved by sulphuric acid, with a deep brown colour, on heating; by nitric acid it is but slowly attacked; boiling solution of potassa dissolves the iodine and leaves the codeine behind. On passing sulphuretted hydrogen through the solution, sulphur is precipitated, and from the acid liquor, colourless iodate of codeine crystallizes on cooling. Nitrate of silver precipitates instantaneously iodide of silver; the entire amount of iodine is, however, not separated

Dicyano-
codeine.

Dicyano-codeine.—Cyanogen-gas is readily absorbed by a saturated solution of codeine in alcohol; the liquid at first yellow, then brown, gradually assumes the odour of hydrocyanic acid, and then deposits crystals, the quantity of which increases on continuing the introduction of cyanogen. They are purified by recrystallization from a mixture of alcohol and ether, after having passed cyanogen-gas through the solution in order to remove some codeine. Dicyano-codeine thus obtained forms brilliant, six-sided laminæ; its solution in aqueous alcohol is decomposed on evaporation, crystals of codeine remaining behind. Acids also decompose it very speedily; potassa then disengages ammonia, and, after a while, hydrocyanic acid. Analysis gave the formula $C_{40}H_{21}N_3O_6 = C_{36}H_{21}NO_{61} 2 C_2N$.

Decomposition of Codeine by the Alkalies.—On heating codeine with 4 or 5 parts of potassa- or soda-lime in an oil-bath to from 120° to 175° , ammonia and an aqueous liquid of a peculiarly pungent odour are given off, from which potassa separates in addition to ammonia and a very small quantity of a crystalline basic body, two volatile bases, a gaseous one, viz.: *methylamine* and an oily one which Anderson recognized as propylamine (metacetamine). He separated them for the purpose of analysis by saturating the alkaline liquid with hydrochloric acid, evaporating to dryness and treating with absolute alcohol, when sal-ammoniac was left undissolved. The filtrate was then mixed with an alcoholic solution of bichloride of platinum and the precipitated double-salts dissolved in hot absolute alcohol to which a little water had been added. On cooling, bichloride of platinum and methylamine was deposited. By addition of ether, to the evaporated mother-liquor, bichloride of platinum and propylamine was separated, which is easily recrystallized from water. The contents of the retort are of the colour of cinnamon and dissolve in water with a dark colour; acids precipitate from this solution a brown, amorphous, still nitrogenous body, not farther examined by Anderson. —The acid formed by the action of nitric acid and codeine, which is insoluble in water, as well as the analogous product of decomposition of narcotine by nitric acid, yield on being boiled with potassa a volatile base in considerable quantity, which, according to a preliminary notice of Anderson(1), is only methylamine. Morphine, strychnine, piperine and nicotine, when treated first with nitric acid and then with potassa, produce also volatile bases, a closer investigation of which, by Anderson, may be expected.

in this way (of 56 per cent only 42 to 43 per cent). The analyses made by Anderson lead to the formula $C_{36}H_{21}NO_6 + J_3$. The iodine was determined by igniting the compound with carbonate of potassa, because a loss of iodine was occasioned in every instance when quicklime was used. Anderson terms this compound *Tri-iodo-codeine*.

(1) Ann. Ch. Pharm. LXXV, 80; Compt. Rend. XXXI, 136; Arch. Ph. Nat. XV, 54; Chem. Gaz. 1850, 363.

Narcotine.—According to a preliminary communication of Th. Wertheim(1), narcotine is decomposed when heated with an excess of hydrated potassa or soda from 220° to 250°, propylamine, C_6H_9N , being given off which passes over in a concentrated aqueous solution. He adds some remarks on the constitution of narcotine, the discussion of which we defer until the detailed treatise has been published.

Strychnine.—According to Elderhorst(2), concentrically grouped prisms, frequently upwards of $1\frac{1}{2}$ inch in length, of *hydrofluorate of strychnine* crystallize on evaporating a concentrated solution of strychnine in hydrofluoric acid. These crystals are four-sided prisms with rhomboidal section and belong to the trimetric system. This salt is readily soluble in hot water, less so in cold, and a little more easily in hot alcohol; it is insoluble in ether. Its solution has an acid reaction. When heated it loses water, becomes red and is decomposed. The analysis led to the formula, $C_{42}H_{22}N_2O_4, HO, HFl + 3 HFl + 3 HO$. This salt loses 3 equivs. of water over sulphuric acid, and at 100° also the fourth equiv.—Strychnine likewise dissolves readily in hydrofluosilicic acid with formation of hydrofluorate and separation of silicic acid.—*Oxalurate of strychnine* does not appear to exist. On boiling strychnine with parabanic acid, oxalate of strychnine crystallizes from the hot filtered solution in long, flat, yellow prisms, which are, when dried at 100°, $=C_{42}H_{22}N_2O_4, HIO, C_2O_3$. The crystallized salt contains 4 equivs. of water (found 9.88, calculated 9.51 per cent) which it gives off at 150°.—A solution of strychnine in hippuric acid, saturated at a boiling heat, and made for the purpose of preparing *hippurate of strychnine*, yielded on evaporation first a syrup, then an amorphous, transparent mass, which only after some months, became solid and white, and consisted then of a mammillary aggregate of microscopic needles.

Brucine.—From a solution of brucine in warm hydrofluoric acid, according to Elderhorst, *hydrofluorate of brucine* crystallizes on cooling in the form of small, colourless, well-defined prisms, belonging to the trimetric system; they are readily soluble in water, and but slightly so in alcohol. They lose at 100° 3.34 per cent of water.

Atropine.—Rabourdin(3) takes advantage of the solubility of atropine in chloroform for the purpose of preparing this base. The juice of belladonna, gathered shortly before coming into flower, is heated to 80° or 90° in order to separate the albumen; the filtrate, when cold, is then shaken for one minute with 4 grms. of caustic potassa and 30 grms. of chloroform to every litre of fluid. After standing for half an hour, the chloroform charged with atropine

(1) Ann. Ch. Pharm. LXXIII, 208; Wien. Acad. Ber. January, 1850, 8; Chem. Gaz. 1850, 141.

(2) Loc. cit. p. 285.

(3) Ann. Ch. Phys. [3] XXX, 381; J. Pharm. [3] XVIII, 407; Instit. 1850, 331; J. Pr. Chem. LI, 256.

Atropine. settles in the form of a greenish, oily layer, which is washed with water, the supernatant liquor being first removed. The chloroform is then distilled off in the water-bath, and the atropine extracted from the residue in the retort by means of dilute sulphuric acid, which leaves a green resin undissolved. On mixing the colourless filtrate with a slight excess of carbonate of potassa, atropine is precipitated which crystallizes in beautiful needles, by spontaneous evaporation of its alcoholic solution.—When the fresh herb cannot be procured, the officinal extract of belladonna may also be used; from 30 grms. of it Rabourdin has obtained 0.160 grms. of atropine, by dissolving the extract in 100 grms. of water and mixing it with 2 grms. of potassa and 15 grms. of chloroform.

Planta(1) has analyzed atropine, and confirmed the formula $C_{34}H_{23}NO_6$, given by Liebig for this base. Atropine melts at 90° , and volatilizes partly undecomposed at 140° ; it is soluble in 299 parts of water of the ordinary temperature, in alcohol in almost every proportion, but somewhat less so in ether; its aqueous solution has a strong alkaline reaction. Planta did not succeed in producing crystallizable salts with sulphuric and hydrochloric acids. Potassa, ammonia and carbonate of ammonia produce in concentrated solutions of the salts of atropine pulverulent precipitates, readily soluble in an excess of the precipitating substance; they are not precipitated by carbonate of ammonia, bicarbonate and phosphate of soda. Bichloride of platinum forms a pulverulent, resinous; terchloride of gold a sulphur-coloured, crystalline double salt, the analysis of which led to the formula $C_{34}H_{23}NO_6$, HCl , $AuCl_3$. Protochloride of mercury produces a precipitate in concentrated solutions only; potassio-iodide of mercury yields a whitish, caseous; tincture of iodine a kermes-brown; tannin, in the hydrochloric solution, a dense flocculent; picric acid a sulphur-yellow precipitate. Atropine is not precipitated by sodio-chloride of iridium, sulphocyanide of potassium, iodide of potassium and iodic acid.

Daturine.—Planta also analyzed daturine, and found that this base is identical with atropine in its deportment, as well as in its composition. He subjected to analysis the uncombined daturine and the double salt with terchloride of gold, and obtained the same results as in the case of atropine.

Aconitine.—Aconitine has also been analyzed by Planta(1). The base was procured from Mr. Merck; previously to its being analyzed it was dissolved in ether, the syrup left after the removal of the ether was dissolved in absolute alcohol, and the alcoholic solution poured into cold water kept stirred, when pure aconitine was precipitated in the form of a flocculent powder. Aconitine melts at 80° , and is decom-

posed at a temperature little exceeding 120° ; its solution has a strong alkaline reaction, and is completely neutralized by acids, without, however, forming crystallizable salts in combination with them.—Potassa, ammonia and carbonate of potassa produce in hydrochlorate of atropine, white flocculent precipitates but slightly soluble in an excess. Aconitine is not precipitated by carbonate of ammonia, bicarbonate and phosphate of soda. Protochloride of mercury and sulphocyanide of potassium produce white, caseous; tannic acid, on addition of a drop of hydrochloric acid, flocculent; picric acid, sulphur-coloured; and tincture of iodine, kermes-brown precipitates. Terchloride of gold throws down a yellowish-white double salt, but little soluble in hydrochloric acid; bichloride of platinum produces no precipitate in solutions of equal concentration. Planta calculates the formula $C_{60}H_{47}NO_{14}$ from his analyses of the pure base and of its double salt with terchloride of gold; hydrochlorate of terchloride of gold and aconitine is $C_{60}H_{47}NO_{14}, HCl, AuCl_3 + 2 HO$. 1 equiv. of aconitine absorbs 2 equivs. of gaseous hydrochloric acid (found 12.84 per cent, calculated 13.41 per cent).

Caffeine.—Rochleder(1) has made farther additions to his investigations of caffeine. The following forms a supplement to his former communications(2).

When caffeine, mixed with water to a thick paste, is treated with chlorine, a mixture of several substances is formed, varying according to the longer or shorter duration of the action, whilst the base gradually disappears. When the process is interrupted before all the caffeine is decomposed, and the mass evaporated, granular crystals of amalic acid separate, and immediately after this substance chloro-caffeine, in the form of white light flakes, and crusts. On farther evaporating the liquid, filtered off from the impure chloro-caffeine, a reddish-yellow syrup is left which becomes solid on cooling, and from which, by pressing it through fine linen, a crystalline mass is obtained—*cholestrophane*; whilst in the thick liquid, hydrochlorate of methylamine is found. During the evaporation a body escapes in addition to hydrochloric acid and chlorine, which has the odour of chloride of cyanogen and a pungent effect upon the eyes. Cholestrophane is formed from amalic acid by the protracted action of chlorine.

Chloro-caffeine, $C_{16}H_9ClN_4O_4$, when crystallized from water, is obtained as a light voluminous mass, and when recrystallized from alcohol, in the form of needles. Rochleder considers it analogous to caffeine ($HC_2N, C_2H_5N, C_8N_2O_4, C_4H_4$), as a compound of chloride of cyanogen, C_2NCl , with methylamine and the group $C_8N_2O_4, C_4H_4$. By the continued action of chlorine the latter body gives rise to farther products of

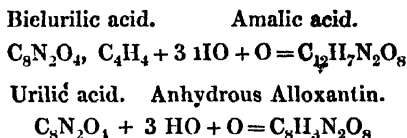
(1) Wien. Acad. Ber. July, 1850, 96; J. Pr. Chem. LI, 398; Chem. Gaz. 1851, 102.

(2) Annual Report for 1849, III, 263.

oxydation, chloride of cyanogen escapes, and the methylamine is converted into the hydrochlorate.

Amalic acid has the formula $C_{12}H_7N_2O_8$. It is obtained in a state of purity by boiling the impure acid with absolute alcohol, in which it is but little soluble, and then dissolving it in hot water when it crystallizes on slow cooling in the form of large crystals similar to alloxantin. The crystals are colourless; they become rose-coloured in the air, and lose nothing in weight at 100° . Their solution slightly reddens litmus, is rendered dark-blue by salts of protoxide of iron mixed with an alkali, and violet by potassa, soda and baryta, this colour disappears on heating, and when baryta has been used a white gelatinous precipitate is formed at the same time. Amalic acid colours the skin red after some time, and imparts to it a nauseous odour; it reduces the salts of silver. On heating, it becomes first yellow, and then forms with water a solution of the colour of permanganate of potassa.

Rochleder assumes amalic acid to be formed from the group $C_8N_2O_4$, C_4H_4 (which he term, *bielurilic acid*), contained in caffeine along with methylamine, by taking up 3 equivs. of water and 1 equiv. of oxygen, in the same manner as alloxantin and urea are formed from the hypothetical urilic acid, which is coupled in urilic acid with $C_2H_2N_2$:



Alloxantin can take up 2 equivs. more water.

In contact with air and ammoniacal gas, moistened amalic acid immediately becomes rose-coloured, then violet, and lastly brownish-red. The mass thus obtained being dissolved in warm alcohol, or in water of 90° , four-sided prisms crystallize on cooling, of the colour of cinnabar, 2 faces of which reflect the light with a golden hue. The solution of this compound, which Rochleder terms *murexoin*, is exactly similar to that of murexide; it does not, however, become blue by potassa, but, on the contrary, colourless; it is also decolorized by evaporation. The analysis of this body, dried *in vacuo*, and at 100° , led to the formula $C_{36}H_{23}N_{10}O_{15}$, which Rochleder divides into $3 C_4H_4 + C_{24}H_{11}N_{10}O_{15}$ (murexide—1 HO). It would accordingly be formed from 3 equivs. of amalic acid, just as there are 3 equivs. of alloxantin required for the formation of murexide.

Cholestrophane is formed by the continued action of chlorine on caffeine, at the expense of amalic acid. It is obtained pure by dissolving in alcohol the impure compound prepared as above, when, on rapidly cooling, it crystallizes in the form of iridescent laminæ, and,

on slowly cooling, in the form of broad, silvery, transparent tables, 1 inch in length. It sublimes even at 100° . The analysis gave the formula $C_{10}H_8N_2O_6$. Rochleder explains its formation by the equation $C_{12}H_7N_2O_8 + O - C_2HO_3 = C_{10}H_8N_2O_6$; according to which amalic acid takes up 1 equiv. of oxygen, and parts with 1 equiv. of formic acid. Cholestrophane bears, therefore, the same relation to amalic acid as parabanic acid does to alloxantin; it contains C_4H_4 more than parabanic acid, $C_6H_2N_2O_6$.

Caffeine.

In an analogous manner to parabanic acid, cholestrophane disappears when boiled with potassa, ammonia being given off, and carbonic and oxalic acids formed.

Rochleder has hereby proved the existence of a series of bodies, homologous with alloxantin, parabanic acid, and murexide, and differing from these by $n(C_2H_2)$. It is probable that theobromine, $C_{14}H_8N_4O_4$, yields a series of these bodies lower by C_2H_2 .

Theobromine.—According to Rochleder and Hlasiwetz(1), theobromine behaves exactly like caffeine towards oxydizing agents. On passing chlorine-gas through water which contains theobromine in suspension, the base gradually disappears, and a yellow fluid is obtained, which becomes blue with a salt of protoxide of iron and ammonia, develops with potassa a pungent odour similar to ammonia, and produces purple stains on the skin. Bichloride of platinum forms in this liquid a precipitate crystallizable in yellow tables, which on analysis appeared to be bichloride of platinum and methylamine.

Lobeline.—W. Bastick(2) states that he prepared an organic base from the herb of *Lobelia inflata* (*Indian tobacco*), by a process similar to that by which hyoscyamine is extracted; it is oily, not crystallizable, but forms crystalline salts with the acids, Bastick terms it *lobeline*. It possesses but in a slight degree the odour of the plant, a pungent taste, similar to that of tobacco, is easily soluble in water, alcohol and ether, decomposed by the caustic alkalies, and cannot be volatilized without decomposition.—Reinsch(3) described formerly as lobeline a gummy substance, insoluble in ether, in which he could not observe any basic properties; so did also Pereira(4).

Piperine.—Dauber(5) observed in piperine, monoclinometric prisms ∞P with OP and sometimes $(\infty P \infty)$, $\infty P : \infty P$, in the ortho-diagonal principal section $= 84^{\circ} 42'$, $\odot P : \infty P = 75^{\circ} 31'$.

Furfurine.—In furfurine, Dauber(6) observed small rhombic prisms $\infty P . \infty \tilde{P} \infty . OP$; ratio of the secondary axes, $1 : 0.822$; $\infty P : \infty P = 97^{\circ} 10'$; cleavage parallel to $\infty \tilde{P} \infty$.

(1) Wien. Acad. Ber. March, 1850, 266.

(2) Pharm. J. Trans. X, 270.

(3) Jahrb. Pr. Pharm. V, 292; Berzelius' Jahresber. XXIV, 646.

(4) Chem. Gaz. 1843, 521; Berzelius' Jahresber. XXIV, 646.

(5) Ann. Ch. Pharm. LXXIV, 204.

(6) Ibid.

Nicotine.

Nicotine.—J. Bödeker, Jun.(1) has described some compounds of nicotine. On adding a saturated solution of protochloride of mercury to a solution of nicotine in dilute hydrochloric acid, until the precipitate at first formed ceases to dissolve, clear, colourless, or slightly yellow crystals of chloride of mercury and nicotine(2), sometimes $\frac{1}{4}$ inch long, are formed after twenty-four hours; they are but little soluble in cold water and in alcohol, and are decomposed by hot water, with the formation of a brown resinous body. In acidulated water they are soluble, without decomposition. Analysis led to the formula $C_{10}H_7N$, 3 HgCl. According to Wöhler, this compound is suitable for the preparation of pure nicotine from the impure and brown one.—Iodide of mercury and nicotine, according to Bödeker $C_{10}H_7N$, HJ + HgJ, is obtained in small yellow prisms, by mixing a solution of nicotine in hydriodic acid, with a saturated solution of iodide of mercury in the same acid, when, after some time, the salt crystallizes. It behaves towards water and alcohol like the preceding compound.—On mixing a neutral solution of nicotine in dilute hydrochloric acid with an equal bulk of a saturated solution of cyanide of mercury, a mercury-salt is obtained in silky, colourless prisms, united into tufts, soluble in cold and hot water, as well as in alcohol, without suffering decomposition. The solution is not precipitated by potassa; this, however, imparts a red colour to the crystals; with hydrochloric acid, they give off hydrocyanic acid. An analysis yielded 50.85 per cent of mercury, 17.76 per cent of chlorine, and 2.46 per cent of cyanogen. Bödeker leaves it undecided whether this compound is $=C_{20}H_{14}N_2$, 5 HgCl, HgCy, or $=C_{10}H_7N$, 2 HgCl, HgCy.

Conicine.—According to R. Wagner(3), conicine may be considered as dibutylamine, C_8H_{17} , C_8H_7 , HN, [assuming Gerhardt's formula, $C_{16}H_{15}N$, and considering the formation of butyric acid, observed by Blyth(4)]; it would accordingly be ammonia, in which 2 equivs. of H are replaced by 2 equivs. of butyryl, C_8H_7 (corresponding to acetyl, C_4H_3). Should conicine in reality possess this constitution, then its artificial production from butylamine, C_8H_9N , and bromide of butyryl, C_8H_7Br , according to Hofmann's method, might be expected; for $C_8H_9N + C_8H_7Br = C_{16}H_{15}N + HBr$. Conicine, with the formula $C_{16}H_{15}N$, is metameric with cyanide of cœnanthyl, C_2N , $C_{14}H_{15}$, or with the nitrile of caprylic acid.

(1) Ann. Ch. Pharm. LXXIII, 372.

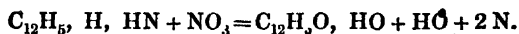
(2) Chloride of mercury and nicotine forms, according to Dauber (Ann. Ch. Pharm. LXXIV, 201), large brilliant rhombic crystals ∞P . $\infty \check{P} 2$. $\infty \check{P} \infty$. $\infty \bar{P} \infty$. $\check{P} \infty$; in the brachydiagonal principal section $\infty P : \infty P = 100^\circ 40'$, $\infty \check{P} 2 : \infty \check{P} 2 = 62^\circ 10'$, $\check{P} \infty : \check{P} \infty = 114^\circ 6'$; principal axis : macrodiagonal : brachydiagonal = 1 : 1.542 : 1.280; cleavage parallel to $\infty \bar{P} \infty$.

(3) J. Pr. Chem. LI, 238.

(4) Annual Report for 1849, III, 266.

Artificial Volatile Bases.—A paper published by Stenhouse(1), on the formation of volatile organic bases, has already been communicated in its main points in the Annual Report for 1849, III, 268.

Aniline.—A. W. Hofmann(2) confirms the statement of T. S. Hunt(3), that aniline is converted into phenol by the action of nitrous acid, nitrogen being given off and water formed, according to the equation :



On passing nitric acid through a mixture of aniline and nitric acid, as Hunt states, Hofmann obtained a brown, resinous mass, containing no phenol, or at best mere traces, but a beautiful crystallizable body, nitro-phenol, $C_{12}H_5(NO_2)O_2$, which may be obtained in larger quantities by subjecting aniline to the action of a mixture of nitric and arsenious acids. When, however, hydrochlorate of aniline is treated with nitrite of silver, or of potassa (such as is obtained by strongly fusing nitre), nitrogen is given off copiously, whilst at the same time a dark oil is separated, from which pure phenol can be prepared by dissolving in ether, evaporating, distilling with water, and rectifying the distillate over anhydrous phosphoric acid. The identity of this product with phenol has been established by Hofmann by analysis.

This transformation of aniline into phenol induced Hofmann to make some analogous experiments with the bases of the series $C_nH_{(n+3)}N$, with a view of obtaining in this manner the alcohols corresponding to propylamine and butylamine, which are as yet unknown. The changes those bases undergo by nitrous acid are, however, only approximately analogous to those of aniline. On putting a crystal of nitrite of potassa into a solution of hydrochlorate of ethylamine, mixed with its bulk of hydrochloric acid, a vivid disengagement of nitrite of oxide of ethyl immediately ensues, the vapour of which, when lighted at the mouth of the test-tube, burns with a flame, the edges of which are coloured light green. The decomposition, therefore, takes place according to the equation $C_4H_7N + 2 NO_3 = C_4H_5NO_4 + 2 HO + 2 N$. Simultaneously, however, with the nitric ether, even when an acid solution is used, a yellow aromatic oil is formed, of a sweet, acid taste, and a high boiling-point, but not in sufficient quantity to admit of a closer investigation.

This mode of decomposition was confirmed in a more evident manner with the less volatile amylamine. On heating a solution of nitrite of potassa in a flask connected with a condenser, and gradually

(1) Chem. Soc. Qu. J. III, 309, Phil Trans for 1850, Part I, 47.

(2) Ann Ch Pharm LXXV, 356, Chem Soc Qu. J III, 231, J. Pharm. [3] XVIII, 399.

(3) Annual Report for 1849, III, 269.

Aniline.

adding an acidulated solution of hydrochlorate of amylamine through a funnel-tube, an aqueous distillate is obtained, with an odour of nitrite of oxide of amyl, and a supernatant oil of a higher boiling-point, from which fusel-oil was reproduced by treatment with sulphuretted sulphide of potassium: $C_{10}H_{11}NO_4 + 6 HS = C_{10}H_{12}O_2 + NH_3 + 2 HO + 6 S$. There are, however, other substances formed besides nitrite of oxide of amyl, inasmuch as that portion of the aromatic oil which boils at a higher temperature deposits, on standing, crystals of a fatty lustre.

Propylamine and butylamine are likewise transformed into the nitrites of oxide of propyl, $C_6H_7NO_4$, and of oxide of butyl, $C_8H_9NO_4$, respectively, by the action of a nitrite, and there can be no doubt that a means is thus given of preparing the corresponding alcohols, when we once succeed in preparing larger quantities of these bases.

Hofmann found, finally, that a mixture of a strongly acid solution of brucine in hydrochloric acid with nitrite of potassa yields, on distillation, a considerable quantity of the same gas (burning with a flame with green edges) which, according to the experiments of Gerhardt(1), is obtained by the direct treatment with nitric acid. The formation of methylamine from caffeine, of propylamine from narcotine, codeine, &c., appears to prove that the natural organic bases are compounds, coupled with bases homologous with ammonia, which must yield the same products as the volatile bases just mentioned, by the action of nitric acid, in consequence of the nitrous acid set free by the process of oxydation.

Toluidine.—According to W. Wilson(2), toluol (the material for preparing nitro-toluol and toluidine) is obtained best, and in large quantities, from the hydrocarbons of coal-gas naphtha, viz.: from that portion which passes over between 100° and 120° ; this is mixed with half its weight of concentrated sulphuric acid, by which means, on repeated distillations, a constant boiling-point is obtained. The boiling-point of toluol is 110° , that of nitro-toluol, prepared from it in the usual way, between 220° and 225° . Wilson found that the transformation of nitro-toluol into toluidine proceeds much more rapidly by using sulphuretted sulphide of potassium, instead of sulphide of ammonium.

Metoluidine.—On passing gaseous chloride of cyanogen over toluidine, spread in a bent tube into a thin layer, a resinous mass is obtained, almost exclusively consisting of the hydrochlorate of a new base, *metoluidine*, $C_{30}H_{17}N_3$. Its formation is analogous to that of melaniline(3).

(1) Annual Report for 1847 and 1848, I, 485.

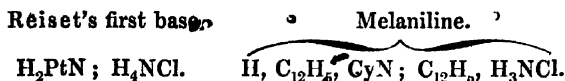
(2) Chem. Soc. Qu. J. III, 154; Chem. Gaz. 1850, 258; Ann. Ch. Pharm. LXXVII, 216.

(3) Annual Report for 1847 and 1848, I, 508.



Metoluidine.

In order to prepare the pure base the mass is dissolved in water, acidulated with hydrochloric acid, the filtrate then mixed with potassa, and the white precipitate thus formed boiled with it, for the purpose of removing toluidine. The residue, after being washed, is crystallized from alcohol. Metoluidine forms crystalline tables, but slightly soluble in cold, and rather more so in hot water. Its hydrochloric solution gives a dark yellow precipitate with bichloride of platinum, which is $\text{C}_{30}\text{H}_{17}\text{N}_3, \text{HCl}, \text{PtCl}_2$, according to Wilson's analysis. Wilson draws attention to the analogy existing between melaniline, metoluidine, and one of Reiset's platinum-bases, on comparing the formulæ of their chlorides written in the following manner :



A. Wurtz(1) has published an extensive investigation of the chemical relations of the organic bases analogous to ammonia, which have been discovered by him. We have to add the following to our former communication(2) on this subject.

Methylamine.—Methylamine-gas has a spec. grav. of 1.08 at 43°, according to the determinations of Izarn; calculated for 4 vols. = 1.0731; below 0° it condenses to a very mobile liquid, which does not solidify in a mixture of ether and solid carbonic acid. It is the most soluble of all known gases; 1 vol. of water dissolves at 120.5, in round numbers, 1150 vols., at 25°, 959 vols. of it. It differs from ammonia-gas by its burning with a yellow flame when brought in contact with a lighted body, water, carbonic acid and nitrogen being produced, which are mixed with some cyanogen, or hydrocyanic acid, when the combustion is incomplete.—Potassium causes at first, by application of a gentle heat, only an inconsiderable increase of the volume of the gas, probably because a compound, $\text{C}_2\text{H}_3, \text{H}, \text{KN}$, analogous to the amide of potassium, is formed; at a higher temperature the volume of the gas increases, 10 vols. of hydrogen, besides cyanide of potassium, being produced from 4 vols. of methylamine-gas. At a red heat methylamine-gas is decomposed, according to the equation $3 \text{C}_2\text{H}_5\text{N} = \text{NH}_3, \text{C}_2\text{NH} + \text{C}_2\text{NH} + \text{C}_2\text{H}_4 + \text{H}_6$.—It is decomposed by chlorine and bromine, with the formation of hydrochlorate, or hydrobromate of methylamine, and of oily drops, which probably have a composition analogous to dichlorethylamine (page 304). Iodine produces, besides hydriodate of methylamine, a garnet-coloured powder, *di-iodomethylamine*, $\text{C}_2\text{H}_3\text{J}_2\text{N}$, which, on being heated, is

(1) Ann. Ch. Phys. [3] XXX, 443; J. Pr. Chem. LII, 193; Ann. Ch. Pharm. LXXVI, 317 (in abstr.)

(2) Annual Report for 1849, III, 271.

methyl-
amine.

decomposed without explosion; it appears to be decomposed by potassa as well as by alcohol. *Hydrochlorate of methylamine* crystallizes from absolute alcohol in the form of large iridescent tables; it is deliquescent, and melts only above 100° , whereby it differs from hydrochlorate of ethylamine, which melts even in the water-bath; it volatilizes at a higher temperature in dense vapours, like sal-ammoniac. Its solution, when brought in contact with potassium-amalgam, gives off hydrogen, and becomes alkaline, without the formation of an amalgam of methyl-ammonium.—*Bichloride of platinum and methylamine*, C_2H_5N , HCl , $PtCl_2$, forms gold-coloured scales, soluble in boiling water, but insoluble in alcohol; *terchloride of gold and methylamine*, C_2H_5N , HCl , $AuCl_3$, forms beautiful gold-coloured needles, soluble in water, alcohol and ether; *chloride of mercury and methylamine*, C_2H_5N , HCl , $HgCl$, forms very easily soluble voluminous crystals. *Hydrobromate of methylamine*, C_2H_5N , HBr , crystallizes from alcohol in large, very deliquescent tables of a fatty lustre. The hydriodate is similar, and becomes brown in the air. *Nitrate of methylamine*, C_2H_5N , HNO_3 , forms elongated rhombic prisms, similar to nitrate of ammonia; it is deliquescent, readily soluble in water and alcohol, and is decomposed, on being distilled, into gaseous products and oily drops, insoluble in water. *Sulphate of methylamine* is not crystallizable, it is easily soluble in water, insoluble in alcohol, and forms methyl-urea, $C_4H_6N_2O_2$, when evaporated with cyanate of potassa.—*Carbonate of methylamine* is obtained by distilling the fused hydrochlorate with carbonate of lime, in the form of a thick liquid, containing anhydrous salt as a solid mass. On application of a gentle heat, the latter partially dissolves; on cooling the liquid portion, hydrated salt separates in the form of hard, prismatic crystals which are very deliquescent, and volatilize even at the ordinary temperature. The numbers deduced from the analysis led to formulæ between C_2H_5N , CO_2 , and C_2H_5N , HO , CO_2 .—*Protochloride of platinum*, in a concentrated solution of methylamine, is converted into *protochloride of platinum and methylamine*; it is a chromium-green powder, insoluble in water, and its formula, $2(PtCl, C_2H_5N)$, corresponds to that of the green salt of Magnus. On heating this compound in a sealed flask, with an excess of methylamine, for some time in the water-bath, it gradually and almost completely disappears, and on evaporating the nearly colourless filtrate crystals of the compound $C_4H_9PtN_2$, $HCl = C_2H_5N$, C_2H_4PtN , HCl are deposited, corresponding to Reiset's salt. On being heated to 160° it gives off methylamine-gas, and the aqueous solution of the residue deposits, on cooling, small brilliant crystals, containing a platinum-base differing from the preceding, but as yet not more closely examined by Wurtz.

Oxalate of methylamine, C_2H_5N , C_2O_3 , is obtained only with difficulty in crystals; by dry distillation it is converted into *methyloxa-*

mide, $C_4H_4NO_2 = C_2(H, C_2H_3)O_2N$, which can readily be prepared by mixing oxalic ether with methylamine. It crystallizes from hot water in long, interwoven needles. Bincoxalate of methylamine crystallizes more readily than the neutral salt; it forms small tables. It is transformed at 160° into *methyloxamic acid*, 2 equivs. of water being separated; the acid partly remains in the residue, and partly volatilizes in the form of a crystalline sublimate. The greater portion of the salt is, however, hereby converted into neutral salt, yielding on its part methyloxamide, whilst it loses oxalic acid in the form of carbonic oxide, carbonic acid and water. Wurtz analyzed methyloxamate of lime; and found its formula to be: $CaO, C_6H_4NO_5 = CaO, C_4(H, C_2H_3)NO_5$.

Methyl-
amine.

Ethylamine.—Pure ethylamine, C_4H_7N , is a very mobile, perfectly transparent liquid, boiling at $18^\circ.7$, and volatilizing on the hand with the production of intense cold; it does not congeal in a mixture of solid carbonic acid and ether. Its spec. grav. at 8° is 0.6964; the density of its vapour for 4 vols. is, theoretically, 1.5568; Izarn found it at 43° and $773^m.01$ pressure = 1.5767.—Ethylamine is nearly as caustic as hydrated potassa; one small drop produces on the tongue a burning pain and violent inflammation. Its aqueous solution is somewhat viscid, and loses by protracted boiling the whole of the dissolved base. Its deportment towards metallic oxides is in every respect similar to that of methylamine; hydrated protoxide of copper is, however, less soluble in it than in the latter, but alumina is very readily dissolved by ethylamine. On adding ethylamine to a solution of alum a flocculent precipitate is obtained, soluble in an excess of the base, just as in potassa; Wurtz is therefore of opinion that ethylamine may be advantageously employed in lieu of potassa for the separation of alumina from sesquioxide of iron, as soon as it can be prepared by a sufficiently cheap process.—Ethylamine decomposes ammoniacal salts with disengagement of ammonia; on mixing a large excess of the base with sal-ammoniac and evaporating to dryness, hydrochlorate of ethylamine only remains; the separation of ammonia from ethylamine can therefore be effected by fractional saturation with an acid, analogous to the method proposed by Liebig(1) for some acids of the series $C_nH_nO_4$. When passed through a red-hot porcelain tube, ethylamine splits into ammonia, hydrocyanic acid, hydrogen, and a little carbonated hydrogen(2).

(1) Annual Report for 1849, III, 227.

(2) Strecker (loc. cit. p. 282) has given the following new method for the preparation of ethylamine, based upon the decomposition with potassa of the ethamine-sulphuric acid (page 282) discovered by him. The vapour of anhydrous sulphuric acid is passed into ether; the product, crude sulphate of oxide of ethyl, is then shaken with water, freed from ether and saturated with ammonia. The ethamine-sulphate of ammonia formed is boiled with carbonate of baryta or protoxide of lead until all the ammonia is driven off; and then, after the addition of solution of potassa, the ethylamine distilled off, which is liberated by the decomposition of the ethamine-sulphuric acid.

Ethyl-
amines.

By the action of chlorine on ethylamine, heat is generated, and in addition to hydrochlorate of ethylamine, *dichlorethylamine* is formed; ($2 \text{C}_4\text{H}_7\text{N} + 4 \text{Cl} = \text{C}_4\text{H}_7\text{N}, \text{HCl} + \text{C}_4\text{H}_5\text{Cl}_2\text{N} + \text{HCl}$). In order to prepare this body, washed chlorine-gas is passed to saturation through a dilute, well-cooled solution of ethylamine; dichlorethylamine is deposited in the form of a yellow liquid which may be obtained in a pure state by washing it with water and rectifying over chloride of calcium. It is a very mobile fluid, pale yellow, of a penetrating odour, exciting tears, and boiling at 91° ; the vapour explodes when strongly heated in a tube. By an excess of chlorine it is converted into a solid compound, crystallizing in scales. Ammonia dissolves it gradually, and by potassa it is slowly decomposed into chloride of potassium, acetate of potassa and ammonia, whilst at the same time two secondary products are formed, viz.: a chlorinetted gas, escaping in small quantities, and a deposit of some drops of an oily liquid, possessing the disagreeable odour of impure cyanide of ethyl. Wurtz expresses this decomposition by the equation $\text{C}_4\text{H}_5\text{Cl}_2\text{N} + 3 \text{KO} + \text{HO} = \text{KO}, \text{C}_4\text{H}_3\text{O}_3 + \text{NH}_3 + 2 \text{KCl}$. If the constitution of dichloraniline were analogous to that of dichlorethylamine, it would yield, by a similar treatment with potassa, the acid $\text{C}_{12}\text{H}_4\text{O}_4$; since, however, the basic nature of ethylamine has entirely disappeared in the chlorinetted compound, whilst it is still retained by dichloraniline, Wurtz supposes that the rational formula of the former is $\text{Cl}, \text{Cl}, \text{C}_4\text{H}_5\text{N}$, and that of the latter $\text{H}, \text{H}, \text{C}_{12}(\text{H}_3\text{Cl}_2)\text{N}$.—Bromine produces with ethylamine a similar compound.

Iodine forms with a solution of ethylamine, besides hydriodate, a thick bluish-black liquid, *di-iodethylamine*, $\text{C}_4\text{H}_5\text{I}_2\text{N}$, which cannot be distilled without undergoing decomposition. It is soluble in alcohol and ether; potassa decomposes it gradually into iodide of potassium, a small portion of iodate of potassa and a yellow crystalline body, the analyses of which did not lead to a definite result.

Hydrochlorate of ethylamine, $\text{C}_4\text{H}_7\text{N}, \text{HCl}$, is most readily obtained by decomposing cyanic ether with potassa, made to act upon it in a refrigerated, closed flask. After five minutes the ether has disappeared, and the alkaline liquid contains only carbonate of potassa and ethylamine, which is distilled off, received in a little cold water, and neutralized with hydrochloric acid. After being evaporated to dryness, it is crystallized from hot alcohol. It forms large, very deliquescent tables or striated prisms, melting between 76° and 80° , and solidifying again on cooling to a semi-transparent crystalline mass. On application of a higher temperature the salt emits fumes, and begins to boil between 315° and 320° ; if it now be cooled, a milk-white mass is obtained, not farther crystalline, and possessing a melting-point beyond 260° . *Bichloride of platinum and ethylamine*, $\text{C}_4\text{H}_7\text{N}, \text{HCl}, \text{PtCl}_2$, is precipitated by alcohol from concentrated solutions in

form of a yellow powder which crystallizes from hot water in fine orange-coloured tables; *protochloride of mercury and ethylamine*, C_4H_7N , HCl , $HgCl$, crystallizes from alcohol in small white tables; *terchloride of gold and ethylamine*, C_4H_7N , HCl , $AuCl_3$, forms gold-coloured prismatic crystals, soluble in water, alcohol and ether.—On passing dry carbonic acid into anhydrous, refrigerated ethylamine, a pulverulent snow-white mass is obtained, the aqueous solution of which is not precipitated by chloride of barium, except after a short time, and when heat is applied. *It is an anhydrous salt, C_4H_7N , CO_2 .—A compound of ethylamine with sulphuretted hydrogen is easily obtained by a similar process, forming fusible deliquescent crystals, rendered yellow in the air, and the solution of which dissolves freshly precipitated tersulphide of antimony.—*Sulphate of ethylamine* cannot be crystallized; it is deliquescent, and dries up to a gummy mass. It is very soluble in alcohol by which means it may be separated from the salt of methylamine. • In order to separate ammonia, methylamine and ethylamine, the mixture of these bases should be saturated with hydrochloric acid, and the mass obtained evaporated to dryness, then treated with absolute alcohol, when nearly all the sal-ammoniac remains behind; the chlorides dissolved are then converted into sulphates, and separated by means of alcohol which dissolves only the sulphate of ethylamine.—*Nitrate of ethylamine* is deliquescent, and disengages, when heated, a considerable quantity of inflammable gases, burning with a yellow flame, in addition to a brown aqueous distillate, upon which some oily drops are floating; the residue becomes ultimately charred.—Ethylamine emits heat when mixed with protochloride of platinum, and forms *protochloride of platinum and ethylamine*, corresponding to Magnus' salt; it is a brownish compound, insoluble in water, of the formula Pt_2Cl_2 , $2 C_4H_7N$. When this salt is heated in the water-bath with an excess of the base, which is best done in a hermetically closed vessel, it redissolves after a short period; sometimes a black body is left behind, which explodes on being heated. The filtrate deposits, on evaporation, colourless, prismatic crystals, readily soluble in water, but slightly in alcohol; this is the hydrochlorate of a new platinum-base, the analysis of which corresponded approximately to the formula C_4H_7N , C_4H_6PtN , $HCl + 2 H_2O$; the analysis of the sulphate (obtained in the form of a white precipitate by decomposing the hydrochlorate with sulphate of silver, evaporating the filtrate and precipitating with absolute alcohol) led to the formula C_4H_7N , C_4H_6PtN , SO_3 , HO ; the base contained in it corresponds therefore to Reiset's platinum-base, NH_3 , NH_2Pt . The constitution of this series of bases, including the methyl-compound, is according to Wurtz (the names are those which he has proposed, comp. p. 229) :

Platinamine
Reiset's 1st base
 NH_3 ; NH_2Pt
VOL. IV.

Plato-methylamine
 NH_2 , C_2H_5 ; NH , Pt , C_2H_5

Plat-ethylamine
 NH_2 , C_4H_9 ; NH , Pt , C_4H_9 .
X

Ethyl-
amine.

The series corresponding to the second of Reiset's bases most probably also exists :

Platinia		
Reiset's 2nd base	Plato-methylia	Platethylia
$\text{NH}_2 \text{Pt}$	$\text{NH}, \text{Pt}, \text{C}_2\text{H}_3$	$\text{NH}, \text{Pt}, \text{C}_4\text{H}_5$

According to this view amide of potassium, NH_2K , should likewise behave as a strong base, if this compound were not too inconstant on account of the powerful affinities of potassium; in the ammoniacal oxide of copper the base $\text{NH}_3 \cdot \text{NH}_2\text{Cu}$, cupramine, can be assumed, according to Wurtz, which forms a constant compound in the sulphate, $\text{NH}_3, \text{NH}_2\text{Cu}, \text{SO}_3, \text{HO}$.

Oxalate of ethylamine, $\text{C}_4\text{H}_7\text{N}, \text{HO}, \text{C}_2\text{O}_3$ crystallizes in right rhombic prisms. When heated, it is readily converted into *ethyloxamide*, $\text{C}_6\text{H}_6\text{NO}_2$, with the loss of 2 equivs. of HO ; this is also produced by the action of ethylamine on oxalic ether, according to the equation $\text{C}_4\text{H}_5\text{O}, \text{C}_2\text{O}_3 + \text{C}_4\text{H}_7\text{N} = \text{C}_4\text{H}_6\text{O}_2 + \text{C}_4\text{H}_6\text{N}, \text{C}_2\text{O}_2$. It is distinguished from oxamide by its greater solubility in alcohol and in water, from which it crystallizes in needles; it is sublimable in woolly crystals and is decomposed by potassa into oxalic acid and ethylamine. —Ethylamine mixed with an excess of oxalic acid, when fused at 180° , yields a small quantity of *ethyloxamic acid*. —On passing the vapour of ethylamine into a cold vessel containing crystallized acetic acid, a deliquescent, white, crystalline mass of acetate of ethylamine is obtained, which is charred by anhydrous phosphoric acid without the formation of a compound corresponding to acetonitrile. On evaporating a solution of acetic ether in aqueous ethylamine, first in the water-bath and then *in vacuo*, an uncrystallizable syrup of *ethylacetamide*, $\text{C}_5\text{H}_9\text{NO}_2$, is obtained, which differs from acetamide by its liquid state and its volatility; it distils at 200° almost without decomposition. By potassa it is decomposed into ethylamine and acetic acid.

Amylamine.—*Amylamine*, $\text{C}_{10}\text{H}_{13}\text{N}$, is obtained in the pure state, according to Wurtz, by distilling the hydrochlorate with lime; to render it completely anhydrous, it is rectified over hydrated potassa or over baryta. It is a light, colourless, very caustic liquid, the odour of which is like that of ammonia and of the amyl-compounds. Its spec. grav. at $18^\circ = 0.7503$. It boils at 95° , and burns with a luminous flame, pale at the edges. It absorbs carbonic acid from the air, the sides of the vessel becoming covered with a crystalline coating of the carbonate. It is miscible with water in all proportions; the solution shows towards metallic salts, in most cases, the same deportment as ammonia; hydrate of alumina, oxides of copper and silver are soluble in an excess of the base, oxide of cadmium is insoluble; acetate of lead is not precipitated by it. —For the preparation of *hydrochlorate of amylamine*, $\text{C}_{10}\text{H}_{13}\text{N}, \text{HCl}$, the product of the distillation of cya-

nate of potassa with sulphamylate of potassa is used. This is distilled with a concentrated solution of potassa. Cyanurate of amyl is only decomposed when fused with hydrate of potassa. After the reaction is completed, a strong alkaline liquid is obtained in the receiver, sometimes two layers; this distillate is saturated with hydrochloric acid, and the filtrate evaporated in the water-bath. The hydrochlorate, after being recrystallized, forms white scales, greasy to the touch. It is readily soluble in water, and also in alcohol, and is not deliquescent. *Bichloride of platinum* and *amylamine*, $C_{10}H_{13}N$, HCl , $Pt Cl_2$, crystallizes from hot water in gold-coloured tables.—By the action of bromine on amylamine, *hydrobromate of amylamine* and insoluble drops of a bromineted substitution-product are formed. The hydrobromate is not deliquescent and melts at a high temperature with disengagement of a white, inflammable vapour; it is readily soluble in water and in alcohol, and is precipitated from the latter by ether in the form of tables, of the lustre of mother-of-pearl.—Oxalic ether mixed with amylamine rises in temperature and then solidifies into a mass of silky needles, *anyloxamide*. This substance melts at 139° , and then completely volatilizes. It is insoluble in water; from hot alcohol it is almost completely deposited on cooling.

Wurtz decides the question of the constitution of the bases discovered by him in favour of the view, already quoted in our Annual Report for 1849, III, 270, according to which they are to be considered as ammonia in which 1 equiv. of H is replaced by 1 equiv. of an alcohol radical. As a farther proof of this view—which is also supported by the mode of formation discovered by Hofmann, viz.: from ammonia and hydrobromic ether, as well as by the fact that no compounds corresponding to the nitriles can be obtained from them—Wurtz quotes the following experiment made by him. On mixing furfural, $C_{30}H_{12}O_{12}$, with methylamine or ethylamine, the former is dissolved without any reaction whilst cold; on the application of heat, however, the mass blackens, and a black resinous mass separates, which contains only traces of nitrogen. If the ammonia base still contained all the basic hydrogen originally present, a compound would necessarily be formed corresponding to furfuramide, 6 equivs. of $H O$ being eliminated—analogueous to the formation of furfuramide ($C_{30}H_{12}O_{12} + N_2H_6 = C_{30}H_{12}N_2O_6 + 6 HO$)—; this, however, cannot take place, because ethylamine and methylamine contains in 2 equivs. only 4 equivs. of basic hydrogen.

Alcohols and Collateral Matters.—Gerhardt(1) expects to succeed in producing alcohols artificially by the following process.—The alcohol $C_4H_6O_2$, and olefiant gas C_4H_4 , yield, by the action

(1) Laur. and Gerh. C. R. 1850, 401.

Alcohols
and col-
lateral
matters.

of anhydrous sulphuric acid and heat, isethionic acid is formed from sulphomeric with sulphovinic acid. Now isethionic acid differs from sulphovinic acid by not producing alcohol on boiling its aqueous solution, but still it might be possible that in distilling isethionic acid, salts, ether-compounds of the alcohol-series would be formed, just as is the case when sulphovinates are distilled with other salts. Gerhardt intends trying to prepare the homologues of isethionic acid from the homologues of olefiant gas, and from them the ethers of alcohol and lastly the alcohols themselves.

On the artificial preparation of alcohols, compare also page 299.

Respecting the various views on the so-called alcohol radicals, compare page 234.

Wood-spirit.—With regard to the volatile oils contained in wood-spirit, compare under Hydro-carbons and Essential Oils.

Hyposulpho-methylic Acid.—J. S. Muspratt(1) has found that the acid formed by the action of nitric acid on bisulphide of methyl, and formerly termed by him sulpho-methylsulphuric acid is identical with hypsulpho-methylic acid(2); the baryta-salt dried at 100° has the composition $\text{BaO}, \text{C}_2\text{H}_3\text{S}_2\text{O}_5$.

Chloroform.—Gregory(3) has communicated experiments on the purification and the properties of chloroform. The impure chloroform, which produces illness after inhalation, contains chloroform and volatile oils(4); chloroform prepared from wood-spirit contains more volatile oils than that from alcohol; and the impurities of the former are analogous but not identical with those of the latter. Impure chloroform is recognized by the disagreeable odour which it emits after the evaporation of the chloroform, and moistened with it emits after the evaporation of the chloroform a cloth covered with it emits after the evaporation of the chloroform a sulphuric acid when shaken with it; pure chloroform exhibits, in an even plane of contact convex below, impure chloroform recommends one. For the purpose of purifying chloroform, Gregory recommends to shake and leave it in contact with sulphuric acid until this substance is not farther coloured, to remove then the chloroform and to remove it with binoxide of manganese until the sulphurous acid is removed from it. The specific gravity of pure chloroform is, according to him, 1.500 at 15°.—According to Abraham(5), chloroform thus purified rapidly undergoes decomposition and then contains free hydrochloric acid and free chlorine. Christison(6) arrived in

(1) Chem. Soc. Qu. J. III, 22.

(2) Annual Report for 1847 and 1848, II, 4.

(3) Proceedings of the Royal Society of Edinburgh, 1850, No. 39; Pharm. J. IX, 580; Chem. Gaz. 1850, 189.

(4) Compare the investigation of Soubeiran and Mialhe, Annual Report for 1849, III, 281.

(5) Pharm. J. Trans. X, 24.

(6) Pharm. J. Trans. X, 252; Chem. Gaz. 1851, 377.

conclusion, that chloroform keeps well after a *single* treatment with pure sulphuric acid, but that a continued action of sulphuric acid effects decomposition (and in a particularly short time, when it contains some nitrous acid).—According to Robin(1) and Augendre(2) chloroform protects meat from putrefaction (according to the latter, 200 times its quantity).

Chloro-
form.

We may also mention here some substances proved to act anæsthetically. Reynoso(3) recognized this property in the protochloride of carbon, C_4Cl_1 (*protochlorure de carbone*), and in the oil of olefant gas (chloride of ethyl, $C_4H_1Cl_2$); the former possesses a disagreeable odour, but the latter he considers worthy of farther experiments.—Aran(4) recommends, especially for the purpose of producing local insensibility, sesquichloride of carbon (C_4Cl_6), and still more the chloromatted chloride of ethyl. From a communication of Mialhe(5), it appears, that the latter preparation (obtained by the action of chlorine on chloride of ethyl C_4H_5Cl) is a mixture of $C_4H_2Cl_4$ and C_4HCl_5 , boiling between 110° and 130° .

Alcohol.—Schrön(6) has published extensive tables, founded on the well-known table of Tralles, for a readier estimation of the amount of alcohol in aqueous spirits of wine from the spec. grav., this being determined at a temperature between 4° and 25° , and for the conversion of the percentage by volume into that by weight. F. Mayer(7) has also calculated a table, founded on the same basis, which gives the percentage of alcohol by weight for the spec. grav. of aqueous spirits, determined at $15^\circ.5$.

For the purpose of estimating the amount of alcohol in a fluid by its boiling-point(8), J. J. Pohl(9) has examined the boiling-point of various mixtures of alcohol and water. He found that the thermometer remained stationary for a short time at the commencement of the boiling, then slowly rose a little, and then again remained stationary for a somewhat longer period (with about 146 grms. of liquid from 4 to 16 seconds). The temperatures of the latter stationary point for 760^{mm} barometer, are given in the following table by B, the amount of alcohol corresponding to them and expressed in percentage by weight, by A :

A	0	1	2	3	4	5	6	7	8	9	10	11	12
B	100.00	98.79	97.82	96.85	95.90	95.02	94.21	93.43	92.70	92.03	91.40	90.83	90.27

An amount of sugar in the liquor, up to 15 per cent, he says, does

(1) Compt. Rend. XXX, 52.

(2) Compt. Rend. XXXI, 679; Instit. 1850, 362.

(3) J. Pharm. [3] XVII, 441.

(4) Compt. Rend. XXXI, 845.

(5) Compt. Rend. XXXI, 848.

(6) Arch. Pharm. [2] LXII, 257.

(7) Jahrb. Pr. Pharm. XX, 82.

(8) Comp. Annual Report for 1847 and 1848, II, 13; and 1849, III, 282.

(9) Denkschriften der Mathem. Naturw. Classe der Wiener Academie, II; Wien. Acad. Ber. March, 1850, 246 (in abstr.)

Alcohol
ates.

not exert any appreciable influence on the boiling-point (a mixture of 10 alcohol with 15 sugar and 75 water boiling at the same temperature as one of 10 alcohol and 90 water).

Alcoholates.—Respecting the compounds designated alcoholates, comp. p. 205.

Ether.—Hoyer(1) has described an apparatus for the rectification of ether.

Mohr(2) has confirmed the fact that fused chloride of zinc yields ether on being distilled with alcohol, and he found, as has been previously observed(3), that it was hereby partially decomposed into hydrochloric acid, passing over, and into oxide of zinc, remaining behind. He considers this as a proof in favour of his theory of the formation of ether, which has been discussed in last year's Annual Report, p. 283; inasmuch as this experiment shows that, by the transformation of alcohol into ether, the oxygen and hydrogen eliminated from the former was not contained in it in the form of water.

Graham(4) prepared ether by heating alcohol and sulphuric acid, without distillation; the alcohol used was of a spec. grav. 0.841 (83 per cent).—1 vol. of hydrated sulphuric acid was gradually mixed with 4 vols. of alcohol, care being taken to avoid too great a heat; the mixture was then sealed up in a strong glass tube and heated during one hour from 110° to 178° ; after being cooled, the liquid occupied a larger space than before being heated, and was separated into two layers, the upper one consisting of ether, free from sulphurous acid, and the lower one, twice as large and of a pale yellow colour, containing, besides a little ether, chiefly alcohol, water and sulphuric acid, but no appreciable quantity of sulphovinic acid. By heating in the same manner 1 vol. of hydrated sulphuric acid and 2 vols. of alcohol, the mixture becomes brown, and only a very minute quantity of ether is formed; on heating equal vols. of hydrated sulphuric acid and alcohol, a black, thick liquid is formed, but no appreciable quantity of ether. By heating for one hour a mixture of 1 vol. of hydrated sulphuric acid and 8 vols. of alcohol from 140° to 158° , also two layers are formed, an ethereal (upper), and a lower one in the proportion of 1 : 2; by heating it again for one hour to the same temperature, the quantity of the ether formed was not increased. On heating for one hour a mixture of 1 vol. of hydrated sulphuric acid and 4 vols. of alcohol (as in the first experiment) to 158° , ether and a heavier acid liquid was formed in the proportion of 1.1 : 2.65; the latter was slightly yellow, and contained but little sulphovinic acid (it yielded on being neutralized with lime only 4.9

(1) Arch. Pharm. [2] LXIII, 140.

(2) Arch. Pharm. [2] LXIV, 284.

(3) L. Gmelin's Handb. d. Chemie, 4. Aufl. IV, 592.

(4) Chem. Soc. Qu. J. III, 24; Ann. Ch. Pharm. LXXV, 108; J. Pharm. [3] XVIII,

parts of sulphovinate of lime to 83.1 sulphate of lime). A mixture of 100 parts of hydrated sulphuric acid, 48 parts alcohol of 0.841 spec. grav. and 18.5 of water yielded, on being heated for one hour to 143° , a dark, greenish-brown liquid, but no layer of ether; one half of this liquid mixed with half its bulk of water and heated in the same manner, produced only a small quantity of ether; the other half mixed with half its bulk of alcohol and heated in the same way, yielded somewhat more ether than half the volume of the alcohol added.—Crystals of bisulphate of soda, still containing some acid in excess, converted, by a similar treatment, about twice their bulk of alcohol into ether; pure crystals of bisulphate of soda still possessed an appreciable, but smaller power of converting alcohol into ether; glacial phosphoric acid and crystallized phosphate of soda, when heated with alcohol to 182° , did not convert the least quantity of it into ether; chloride of zinc also formed only a trace of ether, perceivable by its odour.—Graham concludes that sulphovinic acid yields, neither by itself nor with water, ether(1), but it does so with alcohol as is also the case with other acid salts of sulphuric acid. He says, in the experiments just described, sulphuric acid acts in such a manner upon alcohol, that it doubles the atomic weight of the hydrocarbon contained in it, it exercises a polymerizing action, just as in the case of oil of turpentin, which, by the action of sulphuric acid upon 20 times its bulk, is converted into terebene and colophene, one of which possesses a higher boiling-point and a higher density of vapour than oil of turpentin itself. The formation of sulphovinic acid is not indispensable for the formation of ether, and, in the experiments quoted, the former even obstructs the latter, inasmuch as, under those conditions which gave rise to a larger quantity of sulphovinic acid, less ether was generated. Sulphuric acid, he says, in this case acts by contact, as has already been stated by Mitscherlich(2).—On heating mixtures of hydrate of oxide of amyl, sulphuric acid and water in various quantities in a sealed tube to 176° , only the hydrocarbons already obtained by Balard were formed.

(1) Buignet (J. Pharm. [3] XVIII, 130) communicates that, according to the experiments of Lhermite and Personne, sulphovinic acid does not produce ether when heated in a sealed tube during one hour, from 140° to 178° .

(2) Graham speaks of a theory of the formation of ether, according to which, ether is disengaged from the sulphovinic acid by evaporation in an atmosphere of the vapour of alcohol and of water. It has been pointed out, in Ann. Ch. Pharm. LXXV, 115, that this theory was certainly contradicted by the experiments of Graham, in which evaporation did not take place; that, however, these experiments do not contradict the explanation of the formation of ether, which is based on the fact that sulphovinic acid, when heated from 125° to 140° , separates into ether and aqueous sulphuric acid; that the conversion of alcohol into ether requires a certain time; that it consists in a succession of chemical actions, which had to be found out by the theory of the formation of ether; and that this was not accomplished by stating the fact that alcohol is decomposed into ether and water by means of sulphuric acid.

Williamson(1) has found that ether is formed by the action of iodide of ethyl upon the compound $C_4H_5KO_2$ (which is produced by decomposing anhydrous alcohol with potassium), ($C_4H_5J + C_4H_5KO_2 = KJ + C_8H_{10}O_2 = KJ + 2 C_4H_5O$). This leaves it undecided whether ether is to be expressed by the formula C_4H_5O , or by $C_8H_{10}O_2$. The correctness of the latter formula (already proposed by Gerhardt, in consideration that the formulæ of all volatile organic compounds should express 4 vols. of vapour) follows, according to Williamson, from the fact, that by the action of iodide of methyl on the compound $C_4H_5KO_2$, not a mixture of two ethers, C_2H_5O and C_4H_5O , is formed, but one ethereal liquid, $C_6H_8O_2$, of a peculiar odour, which is but slightly soluble in water, boils a little above 10° , and is not attacked by the alkali-metals. By the action of iodide of amyl on the compound $C_4H_5KO_2$, an ethereal liquid, $C_{14}H_{16}O_2$, is formed, boiling at 110° , and, according to Williamson's supposition, probably identical with the substance obtained by Balard on decomposing chloride of amyl by an alcoholic solution of potassa, and termed by him oxide of amyl. An ether-like compound, $C_{12}H_{14}O_2$, is formed by the action of iodide of amyl on the compound $C_2H_3KO_2$. Williamson views ether and its analogous compounds as alcohols in which 1 equiv. of H is replaced by 1 equiv. of a hydrocarbon (C_2H_3 , C_4H_5 , &c.) In the ordinary preparation of ether, sulphovinic acid is, according to him, first formed, the formula(2) of which is $C_4H_5S_2O_8$; this then yields with alcohol ($C_4H_5O_2$), ether ($C_4H_5O_2$), and hydrate of sulphuric acid.

Chance(3) concurs with this view; according to him, anhydrous sulphovinate of potassa produces ether, on being distilled with the compound $C_4H_5KO_2$, and the ether-like substance $C_6H_8O_2$ (which he observed as gas at 22°), with the corresponding compound $C_2H_3KO_2$ (prepared from wood-spirit and potassium), &c.

Iodide of Ethyl.—Frankland(1) has investigated the action of solar light on iodide of ethyl. Iodide of ethyl becomes by this influence brown, free iodine being separated; but the decomposition does not proceed any farther after the brown colour has attained a certain intensity; but after removing the free iodine by shaking with mercury, the decomposition continues. For the purpose of examining the

(1) Phil. Mag. [3] XXXVII, 350; Chem. Soc. Qu. J. IV, 106; Ann. Ch. Pharm. LXXVII, 37; J. Pr. Chem. LII, 336; Laur. and Gerh. C. R. 1850, 354; J. Pharm. [3] XIX, 15.

(2) Translated like all the formulæ in Laurent and Gerhardt's notation.

(3) Laur. and Gerh. C. R. 1850, 369; Compt. Rend. XXXI, 521; J. Pr. Chem. LI, 316.

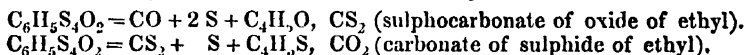
(4) Chem. Soc. Qu. J. III, 322; Ann. Ch. Pharm. LXXVII, 221; J. Pharm. [3] XIX, 308.

products of decomposition more closely, Frankland put a few drops of iodide of ethyl into glass bottles, filled with mercury, and reversed. In the solar light, and more rapidly in the focus of an incompletely polished parabolic reflector, the iodine soon combined with the mercury, whilst at the same time a gas was liberated. This decomposition is the effect of light, and not of heat; iodide of ethyl not being in the least decomposed by mercury even at a temperature of 150° . The decomposition proceeds rapidly, on exposing iodide of ethyl with mercury, in a tube surrounded by water, to the action of solar light; also when the tube is surrounded by a solution of chloride of copper (which absorbs nearly all the caloric rays, but allows nearly all the rays of light to pass); no decomposition, however, of the iodide of ethyl takes place when the tube is surrounded with a solution of bichromate of potassa, which permits the rays of heat to pass, but retains the rays of light.—The gas disengaged by this decomposition of iodide of ethyl was left in contact with a dilute solution of sulphide of potassium for twelve hours (in order to absorb undecomposed vapour of iodide of ethyl, and to exclude oxygen); it proved to be a mixture of 14.34 per cent by volume of olefiant gas (C_2H_4 , absorbed by fuming sulphuric acid), 17.90 of hydride of ethyl (C_2H_6), and 67.76 of ethyl (C_2H_5). Frankland considers, accordingly, that the decomposition of iodide of ethyl under the influence of light, in presence of mercury, proceeds according to the equation, $C_2H_5I + Hg = C_2H_5 + HgI$, a small portion of the ethyl being converted into olefiant gas and hydride of ethyl ($2 C_2H_5 = C_2H_4 + C_2H_6$). That the two latter gases are not found in exactly equal volumes—in the mixture of the products of decomposition—is probably caused, according to him, by their unequal solubility in the solution of sulphide of potassium. He points out the analogy existing in the decomposition of iodide of hydrogen (hydriodic acid), and of iodide of ethyl, by the influence of solar light, where in the former case the simple radical hydrogen, in the latter the compound radical ethyl, is separated; and he draws attention to the circumstance that, in the separation of ethyl from iodide of ethyl by zinc, as well as by solar light, a portion of the ethyl is converted into olefiant gas and hydride of ethyl (in the examination of the former decomposition, formerly termed by him *methyle*, comp. p. 236); in the former case, about $\frac{1}{3}$ of the entire quantity; in the latter, about $\frac{1}{5}$.—The decomposition of iodide of ethyl by sun-light proceeds, in the presence of water, in the same manner and with the same relative proportions of the products of decomposition (ethyl, olefiant gas, and hydride of ethyl), as in the absence of water.—Frankland proposes, in conclusion, to base the construction of an *actinometer*, for measuring the intensity of the chemically acting solar rays upon the estimation of the quantity of gas disengaged from iodide of ethyl by the irradiation of a definite surface of it during a certain time.

Iodide of
ethyl.

Decompositions of binoxysulpho-carbonate of ethyl.

Decompositions of Binoxysulpho-carbonate of Ethyl.—Debus(1) has submitted to a closer examination various decompositions of the compound termed by him *binoxysulpho-carbonate of ethyl*(2), $C_6H_5S_4O_2$.—On mixing alcoholic solutions of this compound and of hydrate of potassa, a considerable quantity of sulphur is separated, and the solution contains xanthate of potassa which may be obtained in a crystalline form after filtering, concentrating *in vacuo*, and cooling to 0° , and which, when purified by dissolving in alcohol, leaves a residue of carbonate of potassa. This decomposition takes place, according to Debus, according to the following equation: $4 C_6H_5S_4O_2 + 4 KO = 3 (C_4H_5O, KO, 2 CS_2) + C_4H_5O, KO, 2 CO_2 + 4 S$. The ethyl-carbonate of potassa divides into alcohol and carbonate of potassa, a portion of the sulphur is separated as such, and the remainder forms with the potassa sulphide of potassium, and probably hyposulphite of potassa.—On mixing a saturated alcoholic solution of binoxysulpho-carbonate of ethyl with sulphuretted sulphide of potassium, much sulphuretted hydrogen is given off, sulphur is precipitated, and xanthate of potassa remains in solution ($C_6H_5S_4O_2 + KS, HS = C_4H_5O, KO, 2 CS_2 + S + HS$).—When submitted to dry distillation, binoxysulpho-carbonate of ethyl began to decompose at 130° ; at 170° the decomposition was so vigorous, that the process could be brought to a close without farther application of heat. The gas given off during the decomposition was carbonic oxide, with some sulphuretted hydrogen and carbonic acid; the residue consisted of sulphur; the liquid passed over possessed a boiling-point, rising from 50° to 210° ; by protracted heating it to 50° , bisulphide of carbon distilled; on farther application of heat, scarcely anything came over till 140° ; between 175° and 190° , chiefly carbonate of sulphide of ethyl (comp. p. 215); between 190° and 200° , scarcely anything; and between 200° and 210° , sulpho-carbonate of oxide of ethyl. Debus assumes that two decompositions of the binoxysulpho-carbonate of ethyl proceed simultaneously:



Debus observed that the bisulphocarbonate of oxide of ethyl (xanthate of oxide of ethyl) possessed a boiling-point of 200° and a spec. grav. = 1.07. He found this compound to be readily prepared by mixing an alcoholic solution of xanthate of potassa with a corresponding quantity of chloride of ethyl, allowing the liquid to stand at from 12° to 18° for five or six days, then adding twice its bulk of water in order to dissolve the chloride of potassium formed, and to separate the bisulphocarbonate of oxide of ethyl, and purifying the product by washing with water, drying over chloride of cal-

(1) Ann. Ch. Pharm. LXXV, 121; Laur. and Gerh. C. R. 1850, 408.

(2) Comp. Annual Report for 1849, III, 289.

Decompositions of binoxy-sulpho-carbonate of ethyl.

cium and rectifying. Besides the reactions and decompositions of this body, already known, Debus describes several others, of which we select the following which were more closely investigated.—An alcoholic solution of bisulphocarbonate of oxide of ethyl mixed with an alcoholic solution of sulphuretted sulphide of potassium, solidified, after some days, to a mass of xanthate of potassa with formation of mercaptane ($2 [C_4H_5O, CS_2] + KS, H_2S = C_4H_5O, KO; 2CS_2 + C_4H_6S_2$).—With an aqueous solution of ammonia, sulphocarbonate of oxide of ethyl undergoes no change; on passing dry ammoniacal gas into an alcoholic solution of it, complete decomposition takes place after some time, and on being distilled sulphide of ammonium and sulphide of ethyl pass over, whilst the residue contains xanthogenamide(1) ($2 [C_4H_5O, CS_2] + 2NH_3 = C_6H_7NS_2O_2 + NH_4S + C_4H_5S$).—Bisulphocarbonate of oxide of ethyl dissolved in as little alcohol as possible, and mixed with a concentrated alcoholic solution of twice its weight of potassa, deposited, on standing at 0° , crystals of a compound $C_4H_5S, KS, 2CO_2$, *carbonate of ethyl-sulphide of potassium*; the mother-liquor contained mercaptane ($2 [C_4H_5O, CS_2] + KO, HO = C_4H_5S, KS, 2CO_2 + C_4H_6S_2$). The carbonate of ethyl-sulphide of potassium crystallizes in needles, or, on gently evaporating the solution, in prismatic crystals, which appear to be isomorphous with those of xanthate of potassa; it is not deliquescent, is readily soluble in water, and also in alcohol of 15° to 20° , but little so at 0° , and very little in ether. When completely dry, it may be kept without decomposition; the aqueous solution, however, undergoes spontaneous decomposition in the course of a few days, and instantaneously when boiled, carbonate of potassa, sulphide of potassium, mercaptane and alcohol being formed; by aqueous acids it is decomposed with formation of alcohol, carbonic acid and sulphuretted hydrogen; it dissolves in concentrated sulphuric acid without evolution of gas, which, however, ensues on adding a little water; dry hydrochloric acid gas produces the same effect as aqueous hydrochloric acid. When heated, it is decomposed; on boiling the aqueous solution with hydrated protoxide of lead and potassa, sulphide of lead, carbonate of potassa and alcohol are formed (the latter could, however, in none of these decompositions be directly detected). Respecting the decomposition by sulphate of copper and by iodine, comp. farther on.—On precipitating a solution of carbonate of ethyl-sulphide of potassium with a quantity of acetate of lead just sufficing, carbonate of ethyl-sulphide of lead, $C_4H_5S, PbS, 2CO_2$, is precipitated in the form of a white crystalline powder; it is insoluble in water, little soluble in alcohol and ether, and is easily decomposed. The corresponding silver- and zinc-compounds also readily undergo decomposition.

Carbonate of sulphide of ethyl, C_4H_5S, CO_2 , the preparation of

(1) Comp. Annual Report for 1849, III, 290.

Decompositions of
binoxysulpho-
carbonate
of ethyl.

which has been given above, (p. 314), is a colourless liquid of an agreeable ether-like odour, boiling between 161° and 162° and has a spec. grav. of 1.032 at 1° . It is insoluble in water, readily soluble in alcohol and ether, not changed by hydrochloric acid, and is decomposed by sulphuric acid only when heated, and by nitric acid only when concentrated acid is used. It may be boiled with protoxide of mercury without being decomposed; with an alcoholic solution of sulphuretted sulphide of potassium it forms carbonate of ethylsulphide of potassium and mercaptane, with an alcoholic solution of potassa in addition to these, also sulphide of potassium; its alcoholic solution is decomposed by dry ammonia, with formation of substances which Debus intends describing more definitely at a future period.

* On decomposing carbonate of ethylsulphide of potassium by sulphate of copper, a white precipitate of ethylsulphide of copper is formed, which soon becomes yellow and converted into a sticky mass, consisting of two compounds. By washing, dissolving in cold alcohol, evaporating the solution *in vacuo*, and digesting the residue with ether, this substance dissolves a compound $C_{12}H_{10}O_8S_3$ and leaves behind another $3(C_4H_5S, CuS, 2CO_2) + Cu_2S$. The latter compound, carbonate of ethylsulphide of copper with subsulphide of copper, is deposited on evaporating the alcoholic solution, in the form of an uncrystalline yellow powder; it is insoluble in water, but slightly soluble in ether, is changed into a tarry mass at 100° , and at a still higher temperature it is decomposed. The other compound, $C_{12}H_{10}O_8S_3$, Debus considers to be bicarbonate of bisulphide of ethyl with bicarbonate of sulphide of ethyl, $C_4H_5S, 2CO_2 + C_4H_5S, 2CO_2$; it is a colourless oil, insoluble in water, and undergoes decomposition on being heated.

On mixing an alcoholic solution of carbonate of ethylsulphide of potassium with iodine until it becomes brown, and then adding twice its bulk of water, a compound $C_6H_5S_2O_4$ separates in the form of a colourless oil; this formation is analogous to that of binoxysulpho-carbonate of ethyl, $C_6H_5S_4O_2$, from xanthate of potassa by iodine. The new compound is decomposed when heated; it can be mixed with sulphuric and nitric acids in the cold without suffering decomposition; with potassa it yields carbonate of ethylsulphide of potassium, sulphide of potassium and sulphur; its alcoholic solution yields with ammoniacal gas, sulphur, sulphide of ammonium, carbonate of ammonia, and probably also urethane.

Debus draws attention to the connection of the compounds which are formed when 2, 4, and 6 atoms of oxygen in the ethylcarbonate of potassa are successively replaced by sulphur:

$AcO, KO, 2CO_2$ (Ethylcarbonate of potassa).

$AcS, KS, 2CO_2$ (Carbonate of ethylsulphide of potassium).

$AcS, KS, 2C_S^O$ ($AcO, KO, 2CS_2$; xanthate of potassa).

$AcS, KS, 2CS_2$ (unknown).

According to Debus, the two middle terms of this series are isomorphous, and give by a similar action of other substances corresponding compounds, differing only in so far as the oxygen of the one is replaced by sulphur in the other, and *vice versa*. The deportment of these two terms towards sulphate of copper is also analogous; for the body which Zeise considered as xanthate of suboxide of copper is, according to Debus, a compound of xanthate of copper with subsulphide of copper $3(\text{C}_4\text{H}_5\text{O}, \text{CuO}, 2 \text{CS}_2) + \frac{1}{2} \text{Cu}_2\text{S}$.—The boiling-point regularly increases by this successive replacement of oxygen with sulphur by about 37° , for 1 atom S entering in lieu of 1 atom O; $\text{C}_4\text{H}_5\text{O}, \text{CO}_2$ boils at 126° ; $\text{C}_4\text{H}_5\text{S}, \text{CO}_2$ at 162° ; $\text{C}_4\text{H}_5\text{O}, \text{CS}_2$ at 200° ; $\text{C}_4\text{H}_5\text{S}, \text{CS}_2$ at 237° ; Löwig and Schweizer found a lower boiling-point for the latter compound; but Debus convinced himself that the pure substance $\text{C}_4\text{H}_5\text{S}, \text{CS}_2$, the formula of which he confirmed, boils between 237° and 240° .—Debus finally is of opinion that the xanthates are certainly to be considered as compounds of oxides with bisulphide of carbon (xanthate of potassa, as $\text{C}_4\text{H}_5\text{O}, \text{KO}, 2 \text{CS}_2$, and not, as Berzelius assumed, as $\text{C}_4\text{H}_5\text{O}, \text{KO}, 2 \text{CO}_2 + 2 [\text{C}_4\text{H}_5\text{S}, \text{KS}, 2 \text{CS}_2]$), and he considers that the compounds lately discovered by him consist of sulphides (sulphide of ethyl and metallic sulphides) and carbonic acid.

Decompositions of binoxy-sulpho-carbonate of ethyl.

Ethylo-hyposulphuric Acid.—As a product of decomposition of mercaptane by nitric acid, Löwig and Weidmann discovered an acid which was designated as sulphethylo-sulphuric acid, and the salts of which were considered as $\text{RO}, \text{C}_4\text{H}_5\text{S}_2\text{O}_4$, in the dry state. J. S. Muspratt(1) stated that this acid is also formed by decomposing bisulphide of ethyl with nitric acid, whilst, by decomposing sulphocyanide of ethyl with nitric acid, ethylo-hyposulphuric acid is formed, the salts of which are $\text{RO}, \text{C}_4\text{H}_5\text{S}_2\text{O}_5$. Laurent and Gerhardt assigned the latter composition also to the salts of the so-called sulphethylo-sulphuric acid; by adopting the formula given above, an amount of 1 equiv. of water had to be assumed, even after drying at 100° , according to most analyses. J. S. Muspratt(2) has now found that bisulphide of ethyl (best prepared by distilling equal parts of saturated solutions of sulphovinate of lime and tersulphide of potassium, washing the distillate with water, and repeatedly rectifying over chloride of calcium) gives, with nitric acid, the same acid as sulphocyanide of ethyl, and that the baryta-salt of this acid, when crystallized, is $\text{BaO}, \text{C}_4\text{H}_5\text{S}_2\text{O}_5 + \text{H}_2\text{O}$ (HO escapes at 100°). The same composition has now been found by Löwig(3) for the baryta-salt of the so-called sulphethylo-sulphuric acid.

(1) Annual Report for 1847 and 1848, II, 18.

(2) Chem. Soc. Qu. J. III, 18.

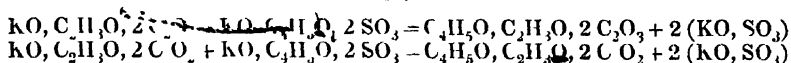
(3) Ann. Ch. Pharm. LXXV, 349; J. Pr. Chem. L, 340. On treating mercaptane ($\text{C}_4\text{H}_5\text{S}_2$) with nitric acid, Löwig and Weidmann (Pogg. Ann. XLIX, 323; Berzelius' Jahresber. XXI, 431) obtained also an oily liquid $\text{C}_4\text{H}_5\text{S}_2\text{O}_2$, which they designated as

Nitrite of
oxide of
ethyl.

Nitrite of Oxide of Ethyl.—Jonas(1) observed that by the action of a mixture of strong alcohol and nitric acid upon iron-filings, nitrite of oxide of ethyl was formed, which passes over almost completely and nearly free from acid without external application of heat. This fact had already been arrived at by former observations. In order to prepare this ether, according to J. Grant(2), starch is to be mixed with strong alcohol, then some nitric acid added, and if required a gentle heat applied.—Möhr(3) doubts the existence of nitrite of ethyl or its being contained in the preparation so termed, because he could not observe(4) a decomposition of this body (prepared by distilling alcohol with nitric acid) by distilling it with potassa or by digesting it with an alcoholic solution of potassa.

Acetate of Oxide of Ethyl.—Jonas(5) has described some observations on the formation of acetate of oxide of ethyl with the co-operation of stronger acids. H. Becker(6) and Schenkel and Rieckher(7) have made communications on the best mode of preparing acetate of oxide of ethyl.

Oxalic and Carbonic Ethers of a more Complex Composition.—Chance(8) states that he has obtained by distilling equal equivalents of methyloxalate of potassa ($\text{KO}, \text{C}_2\text{H}_3\text{O}, 2 \text{C}_2\text{O}_3$) or methylcarbonate of potassa ($\text{KO}, \text{C}_2\text{H}_3\text{O}, 2 \text{C}_2\text{O}$) and sulphovinate of potassa, ether-like compounds $\text{C}_{10}\text{H}_8\text{O}_8 (= \text{C}_4\text{H}_5\text{C}_4\text{O}_8 = \text{C}_4\text{H}_5\text{O}, \text{C}_3\text{H}_3\text{O}, 2\text{C}_2\text{O}_3)$ and $\text{C}_8\text{H}_8\text{O}_6 (= \text{C}_4\text{H}_5\text{C}_2\text{O}_6 = \text{C}_4\text{H}_5\text{O}, \text{C}_2\text{H}_3\text{O}, 2\text{CO}_2)$, which he terms *oxalvino-methylide* and *carbo-vinomethylide* and which may be called *ethyl-oxalate of methyl* and *ethylcarbonate of methyl* in accordance with the views now more familiar.



In a second communication(9), Chance describes more minutely the preparation of oxalovinate of methyl $\text{C}_{10}\text{H}_8\text{O}_8$ (he terms it here *oxalmethylvinide*) from oxalovinate of potassa and methyloxalo-

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sulphite of sulphide of ethyl, and by treating this compound with potassa a potassa-salt was formed, in which the anhydrous acid (combined with 2 equivs. of potassa) was said to be  $\text{C}_4\text{H}_5\text{O}_4\text{S}_4$ , they termed this acid bisulphethylo-sulphuric acid. Laurent (Compt. Rend. XXXI, 351, J. Pr. Chem. LI, 242) proposed the formula  $\text{C}_4\text{H}_5\text{O}_{10}\text{S}_4$ , for the (so-called) hydrate of this acid, and is of opinion that it stands in the same relation to ethionic acid, as sulphurous acid to sulphuric acid

(1) Arch. Pharm. [2] LXII, 9.

(2) Pharm. J. Trans. X, 244, Ann. Ch. Pharm. LXXXVI, 282.

(3) Arch. Pharm. [2] LXIV, 47.

(4) Ströcker has confirmed, in 1851, that the substance designated nitrite of oxide of ethyl is really decomposed by alkalis into alcohol and the nitrite of the alkali (Ann. Ch. Pharm. LXXVII, 331).

(5) Loc. cit. sub. (1).

(6) Arch. Pharm. [2] LXII, 163.

(7) Jahrb. Pr. Pharm. XX, 193.

(8) Loc. cit. page 312.

(9) Laur. and Gerh. C. R. 1850, 403.

vinate of potassa. He prepares oxalate of oxide of ethyl by dropping absolute alcohol upon oxalic acid, heated from  $180^{\circ}$  to  $200^{\circ}$ ; this method yields 80 parts by weight of oxalic ether for every 100 parts of oxalic acid. He then converts the oxalate of oxide of ethyl into oxalovinate of potassa by the process of Mitscherlich, dries it at  $100^{\circ}$ , and *in vacuo*, intimately mixes it with an equal weight of dry sulphomethylate of potassa (in order to facilitate the distillation, it is advisable to mix it also with pumice-stone) and distils, in the sand-bath at a gentle heat. The oxalovinate of methyl thus passing over, is freed from a sulphuretted impurity by repeated rectifications over chloride of sodium, it is then dried over chloride of calcium and rectified with protoxide of lead. It then forms a colourless liquid of a slightly aromatic odour, boiling between  $160^{\circ}$  and  $170^{\circ}$  without decomposition; it has a spec. grav. of 1.27 at  $12^{\circ}$ , and the density of its vapour is 4.677 (4.566 calculated for a condensation of  $C_{10}H_8O_8$  to 4 vols.) It burns with a pale flame, blue at the edges. It dissolves in boiling water, and is decomposed into wood-spirit, alcohol, and oxalic acid. The analysis corresponded to the formula  $C_{10}H_8O_8$ ; the quantity of oxalic acid obtained by decomposing it with potassa,

Oxalic and carbonic ethers of a more complex composition.

led to the formula  $\begin{smallmatrix} C_2H_3 \\ H_4H_5 \end{smallmatrix} C_4O_8$ , or  $C_4H_5O$ ,  $C_2H_3O$ , &  $C_2O_3$ . Ammonia instantaneously decomposes this compound, oxamide being separated.—In this latter communication, Chancel states farther, that by distilling xanthate of potassa with its equivalent of sulphomethylate of potassa, *bisulphuretted carbomethylovinid*,  $C_8H_8O_2S_4$  is obtained (ethylocarbonate of oxide of methyl, in which 4 O are replaced by 4 S).—This is a pale yellow, transparent liquid, of a sweet taste, and a strong, ethereal, not disagreeable odour; it boils at  $179^{\circ}$  without being decomposed, has a spec. grav. of 1.122 at  $11^{\circ}$ , and the density of its vapour is 4.652 (4.680 calculated for a condensation to 4 vols.) It is insoluble in water, soluble in alcohol and ether; it is easily inflammable and burns with a blue flame, disengaging a considerable quantity of sulphurous acid. Only its amount of carbon and hydrogen was determined and found to correspond to the above formula.

**Stibethyl.**—Löwig and Schweizer(1) have investigated the action of antimonide of potassium upon chloride, bromide and iodide of ethyl, and obtained as a product of this reaction a compound containing carbon, hydrogen and antimony, which they term *stibethyl*. Iodide of ethyl is most suitable for the preparation of stibethyl, on account of

(1) Mittheilungen der Züricher naturf. Gesellsch. Nr. 45 u. 51; Ann. Ch. Pharm. LXXV, 315, 327; J. Pr. Chem. XLIX, 385; L, 321; Pogg. Ann. LXXX, 338; Arch. Ph. Nat. XIII, 298; XIV, 288; Instit. 1850, 172; 1851, 30; Laur. and Gerh. C. R. 1850, 237, 389; Chem. Gaz. 1850, 201, 372, 395, 420. Frankland (Annual Report for 1849, III, 287) supposed a compound of the composition of stibethyl to exist.



Stibethyl.

its being most readily decomposed. Antimonide of potassium<sup>(1)</sup>, triturated with 2 or 3 parts of fine quartz sand, is moistened in a small flask with iodide of ethyl; reaction soon takes place, and iodide of ethyl is volatilized; when iodide of ethyl no longer passes over the flask is connected with a tube and a condenser, filled with carbonic acid, and placed in an atmosphere of this gas; on applying heat to the flask the stibethyl passes over into the receiver (which should contain some antimonide of potassium). This operation is repeated with fresh quantities of antimonide of potassium and iodide of ethyl, and the entire distillate is rectified in an atmosphere of carbonic acid, whereby the vessel hitherto used as a receiver serves as retort. The first portion of the distillate contains iodine, and deposits, on standing for some time, a small quantity of colourless crystals, containing iodine (iodide of stibethyl).—Stibethyl is a limpid, mobile liquid, of a disagreeable onion-like odour, and refracting the light considerably; it has a spec. grav. of 1.3244 at 16°, does not solidify at -29°, and boils at 158°·5 at 730<sup>mm</sup> barometer. In the analysis it was found necessary, for the exact determination of the carbon, to make the combustion with oxide of copper, mixed with from 4 to 5 per cent of chlorate of potassa; the antimony could not be completely oxydized, either by nitric acid or by *aqua-regia*, but was best determined by passing the compound over red-hot quartz sand, from which the antimony was afterwards extracted by means of *aqua-regia*. The composition was thus found to be  $C_{12}H_{15}Sb$ ; stibethyl contains 3 equivs. ethyl to 1 equiv. of antimony, or it can be regarded as antimonetted hydrogen, the hydrogen of which is replaced by ethyl. The density of its vapour was found to be 7.44 (7.50 calculated for a condensation of  $C_{12}H_{15}Sb$  to 4 vols.) Stibethyl readily dissolves in alcohol and ether; one drop of it in contact with the air causes, at first, thick white fumes, and shortly after burns with a brilliant white, very luminous flame; when introduced into oxygen through a fine orifice it burns with a splendid light; fuming nitric acid likewise effects with it a beautiful combustion. Under water the oxydation of stibethyl proceeds very slowly.

Stibethyl,  $C_{12}H_{15}Sb$ , combines with 2 equivs. of oxygen, sulphur, chlorine, &c. Under certain circumstances 2  $C_4H_5$  are separated from it, and a compound,  $C_4H_5Sb$ , *ethyl-stibyl*, is formed. Ethyl-

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(1) Löwig and Schweizer prepared antimonide of potassium by mixing 5 parts of crude cream of tartar with 4 parts of antimony, slowly heating the mixture in a covered crucible until the tartar was charred, then exposing it to a white heat during one hour, and lastly, gradually cooling in a hermetically closed furnace. By this process a crystalline cegulite is obtained, containing 12 per cent of potassium; it decomposes water with violence, and is but slowly oxydized in the air on account of its density; when triturated into a fine powder it evolves heat and ignites, the ignition may, however, be prevented by adding from 2 to 3 parts of fine quartz sand whilst it is pounded.

stibyl differs from stibethyl chiefly by its sulphur-compounds being insoluble in water. All compounds containing ethyl-stibyl give with sulphuretted hydrogen a yellow precipitate, of a disagreeable odour. Ethyl-stibyl and its compounds will be more minutely described by Löwig and Schweizer at a future period.

• By slowly oxydizing stibethyl, a white powder, insoluble in ether, is formed, in addition to a transparent, syrupy mass. The former is *ethyl-stibylic acid*,  $C_4H_5SbO_5$ , the latter *oxide of stibethyl*,  $C_{12}H_{15}SbO_2$ . The largest quantity of oxide of stibethyl is formed when a dilute alcoholic solution of stibethyl is slowly evaporated in a loosely covered vessel (on evaporating an ethereal solution ethyl-stibylic acid is formed); from the residue the oxide of stibethyl is extracted by means of ether; the solution is evaporated to dryness, the residue again dissolved in ether, and this process repeated several times. Oxide of stibethyl is free from ethyl-stibylic acid, when its aqueous solution is not rendered yellow or cloudy by sulphuretted hydrogen. Oxide of stibethyl is best and purest prepared from its sulphate by dissolving in water, precipitating with baryta-water, evaporating the liquid in the water-bath, and treating the residue with alcohol, when a compound of oxide of stibethyl and baryta is dissolved; the alcoholic extract is then decomposed with carbonic acid, and the liquid, filtered off from the carbonate of baryta, evaporated. Pure oxide of stibethyl is also formed by shaking an alcoholic solution of stibethyl with an excess of finely powdered protoxide of mercury, when the latter becomes rapidly reduced.—In its purest state oxide of stibethyl is a tough, limpid, uncrystalline mass, readily soluble in water and alcohol, somewhat less so in ether, and possessing a bitter taste; it does not appear to be poisonous, it is not changed in the air, and is not volatile, when heated in a glass tube it emits white vapours, burning with a bright flame, and leaves a residue containing antimony and carbon. When gently heated with potassium it is decomposed, stibethyl being separated; by fuming nitric acid it is decomposed, with the phenomenon of combustion; dilute nitric and concentrated sulphuric acids dissolve it, and form salts of oxide of stibethyl; hydrochloric and similar acids produce chloride of stibethyl, and the corresponding compounds. Sulphuretted hydrogen effects no apparent reaction; on evaporating a solution of oxide of stibethyl, saturated with this gas, crystals of sulphide of stibethyl are obtained.

*Nitrate of oxide of stibethyl* is formed on saturating dilute nitric acid with oxide of stibethyl, or on dissolving stibethyl in some warm, dilute acid (when nitric oxide is given off, whilst at the same time a small quantity of teroxide of antimony is separated); it is obtained in crystals on evaporating the solution; if the acid solution be considerably concentrated in the water-bath the nitrate is separated in the form of heavy oily drops which, on cooling, solidify in a crystalline

**Stibethyl.** form. By dissolving this salt in a small quantity of water, and allowing the solution spontaneously to evaporate, it is obtained in large rhomboidal crystals,  $C_{12}H_{15}Sb, O_2 + 2 NO_5$ , which melt at  $62^{\circ}\cdot 5$  to a clear liquid, solidifying at  $57^{\circ}$  in a crystalline form; it is readily soluble in water, less so in alcohol, and scarcely in ether; the solutions have an acid reaction and a bitter taste; when heated it deflagrates, like a mixture of saltpetre and charcoal.—*Sulphate of oxide of stibethyl* may be prepared in a direct manner, but is obtained purest by decomposing sulphide of stibethyl with sulphate of copper; it is readily soluble in water, and crystallizes only from the syrupy solution in the form of small white crystals,  $C_{12}H_{15}Sb, O_2 + 2 SO_3$ ; they have a bitter taste, and melt when heated a little above  $100^{\circ}$ .

*Sulphide of stibethyl* is instantaneously formed, with disengagement of heat, when sulphur and stibethyl are brought together under water. It is most readily obtained by boiling a solution of stibethyl in ether with pure flowers of sulphur; the liquid poured off from the sulphur soon solidifies to crystalline needles which are purified by the adhering stibethyl becoming oxydized in the air, and then repeatedly crystallizing the sulphide from ether. Sulphide of stibethyl,  $C_{12}H_{15}Sb, S_2$ , forms a bulky silvery mass of crystals, of a disagreeable odour and a bitter taste; when dry it is not changed in the air, heated to somewhat above  $100^{\circ}$  it melts, and at a still higher temperature it is decomposed, a liquid product, similar to sulphide of ethyl, being formed. Potassium disengages vapours of stibethyl from fused sulphide of stibethyl; the aqueous solution of sulphide of stibethyl precipitates metals from their solutions in the form of sulphides, and yields with dilute acids sulphuretted hydrogen.—*Selenide of stibethyl* is similar as regards preparation and properties; it is, however, soluble and decomposed in the air, selenium being separated.

Iodine and stibethyl instantaneously unite under water, with disengagement of heat. On adding iodine to an ethereal solution of stibethyl, violent boiling ensues for a moment, and the iodine disappears rapidly. *Iodide of stibethyl* is best prepared by adding iodine in small portions to an alcoholic solution of stibethyl, placed in a frigorific mixture, as long as its colour disappears, and then allowing the colourless solution thus obtained to evaporate spontaneously. It crystallizes in colourless needles which have to be recrystallized first from alcohol, and then from ether, in order to free them from a small quantity of a yellow powder, insoluble in ether (a compound of iodine and ethyl-stibyl). Iodide of stibethyl,  $C_{12}H_{15}Sb, J_2$ , possesses in a slight degree the odour of stibethyl; it has a bitter taste, dissolves readily in alcohol and ether, and, without undergoing decomposition, also in water; it melts and solidifies at  $70^{\circ}\cdot 5$ , sublimes unchanged at  $100^{\circ}$ , when in small quantities, and is decomposed at a somewhat higher temperature, whilst thick white vapours are formed. From fused iodide of stibethyl potassium separates instan-

taneously stibethyl. Iodide of stibethyl behaves towards metallic salts, and towards concentrated sulphuric acid, like iodide of potassium. Hydrochloric acid immediately produces with it chloride of stibethyl; chlorine and bromine separate iodine, and so does nitric acid, nitrate of oxide of stibethyl being formed.—Stibethyl, added drop by drop to bromine, inflames. Bromide of stibethyl is prepared by adding a freshly prepared alcoholic solution of bromine to an alcoholic solution of stibethyl, kept cold by ice, as long as the colour of the former disappears, when, on addition of a large quantity of water, bromide of stibethyl is separated in the form of a colourless liquid. When washed and dried by digestion with chloride of calcium, it is  $C_{12}H_{15}Sb, Br_2$ , forming a transparent liquid, strongly refracting light, and possessing the spec. grav. 1.953 at  $17^0$ ; it solidifies to a crystalline mass at  $-10^0$ , has a disagreeable odour, resembling that of turpentin, excites sneezing, is readily soluble in alcohol and in ether, insoluble in water, and is not volatile; it burns with a white flame, disengaging acid vapours, and on distillation yields, amongst other products, a strongly acid liquid of the intolerable odour of chloral. It is decomposed by concentrated sulphuric acid, with disengagement of hydrobromic acid, and by chlorine, with separation of bromine. The alcoholic solution behaves, towards metallic salts like bromide of potassium.—Stibethyl, added drop by drop to chlorine-gas, inflames, and burns with a bright smoky flame. When stibethyl is brought in contact with 1 vol. of dry hydrochloric acid gas,  $\frac{1}{2}$  vol. of hydrogen and chloride of stibethyl are formed. This is likewise produced, with disengagement of hydrogen, by the action of fuming hydrochloric acid on stibethyl. This compound may be obtained pure, and with readiness, by decomposing a concentrated solution of nitrate of oxide of stibethyl with strong hydrochloric acid. Chloride of stibethyl,  $C_{12}H_{15}Sb, Cl_2$ , separates in the form of a colourless liquid which is purified like the bromide. It has a spec. grav. of 1.540 at  $17^0$ , smells strongly of turpentin, possesses a bitter taste, is insoluble in water, readily soluble in alcohol and ether, and remains liquid at  $-12^0$ ; it appears to volatilize, undecomposed, in small quantities, when distilled with water. When heated by itself, it exhibits the same deportment as bromide of stibethyl. Concentrated sulphuric acid disengages from it hydrochloric acid, whilst, *vice versa*, hydrochloric acid precipitates chloride of stibethyl from a solution of sulphate of oxide of stibethyl. In every other respect it behaves like chloride of potassium or sodium.—On mixing the aqueous solutions of 2 equivs. of cyanide of mercury and of 1 equiv. of sulphide of stibethyl, sulphide of mercury and a liquid are formed having the odour and taste of hydrocyanic acid. It behaves towards metallic salts like cyanide of potassium, and contains, therefore, *cyanide of stibethyl*. After twenty-four hours, and in less time when heated, the liquid does not exhibit any longer this deportment; if it be now boiled with potassa,

**Stibethyl.** it produces a copious disengagement of ammoniacal gas. On adding iodide of stibethyl to an alcoholic solution of cyanide of mercury, iodide of mercury is at first precipitated, and after a while redissolved. From the solution a salt is then deposited, in the form of small yellow, hard, brilliant crystals, soluble in water and alcohol, which is most likely a compound of iodide of mercury and cyanide of stibethyl. Dilute hydrochloric acid precipitates from the aqueous solution of this salt iodide of mercury, whilst chloride of stibethyl and hydrocyanic acid are formed.

Löwig and Schweizer regard stibethyl as a radical containing 2 equivs. of ethyl, combined with the adjunct  $C_4H_5$ , Sb. That 2 equivs. of free ethyl exist in this body, is proved in their opinion by the combination of 1 equiv. of stibethyl with 2 equivs. of oxygen, sulphur, &c. In kakodyl, however, 1 equiv. of methyl is united to the adjunct  $C_2H_3$ , As, which consequently combines with only 1 equiv. of oxygen, sulphur, &c. (Kolbe assumes in the kakodyl 2 equivs. of methyl, coupled with 1 equiv. of As; comp. p. 234).

They farther state that, by the action of iodide of ethyl on bismuth-potassium, a compound of ethyl and bismuth is formed, and that phosphorus also produces perfectly analogous compounds.

Laurent and Gerhardt(1) are of opinion, that the base in the compounds designated as salts of stibethyl is  $C_{12}H_{13}Sb$ , and they propose for it the name of *stibethine*. The nitrate of oxide of stibethyl of Löwig and Schweizer is, according to the former,  $C_{12}H_{13}Sb$ , 2 HO, 2  $NO_5$ , chloride of stibethyl,  $C_{12}H_{13}Sb$ , 2 HCl, &c.

**Hydrated Oxide of Amyl.**—On the decomposition of hydrate of oxide of amyl by heat, comp. p. 335.

**Iodide of Amyl.**—Frankland(2), who formerly investigated the decomposition of the iodides of ethyl and methyl by zinc(3), has now extended these inquiries to the iodide of amyl.—In order to prepare iodide of amyl, he gradually dissolved 4 parts of iodine in 7 parts of hydrated oxide of amyl, and introduced, previous to each fresh addition of iodine, a piece of phosphorus into the liquid, until this was rendered colourless. On distilling the thick liquid in an oil-bath, a colourless distillate passed over, whilst a thick, oily, very acid liquid, insoluble in water (probably a compound of phosphorus with oxide of amyl), remained behind. The distillate, which contained a considerable quantity of hydriodic acid, and unchanged hydrate of oxide of amyl, in addition to iodide of amyl, was washed with a little water, and after digestion with chloride of calcium for twenty-four

(1) Laur. and Gerh. C. R. 1850, 399.

(2) Chem. Soc. Qu. J. III, 30; Ann. Ch. Pharm. LXXIV, 41; Ann. Ch. Phys. [3] XXX, 372; J. Pharm. [3] XVIII, 230; Laur. and Gerh. C. R. 1850, 157.

(3) Annual Report for 1849, III, 283 sqq. 286 sqq.

hours, it was rectified. The boiling-point rose from  $120^{\circ}$  to  $146^{\circ}$ , when at the latter temperature, pure iodide of amyl passed over. If this be coloured brown by iodine, derived from hydriodic acid not completely removed, it may easily be rendered colourless by rectification over mercury. Iodide of amyl, the formula of which,  $C_{10}H_{11}J$ , Frankland confirmed, is a colourless liquid, powerfully refracting light, and possessing a slightly ethereal odour, and a sharp, pungent taste; it boils at  $750^{\text{mm}}$  barometer, at  $146^{\circ}$  (Cahours stated  $120^{\circ}$ ); its spec. grav. is  $1.51113$  at  $11^{\circ}.5$ .

Iodide of amyl is acted upon by zinc with more difficulty than iodide of ethyl. In consequence of the readier decomposition of iodide of amyl alone, and with zinc, into hydriodic acid and other gaseous products, the temperature at which the decomposition is effected must be carefully observed. Frankland found it advisable to use an amalgam of zinc, instead of zinc. He introduced pasty amalgam of zinc, granulated zinc (which enters into the amalgam in the same proportion as the latter is deprived of its zinc by the action of the iodide of amyl) and iodide of amyl into a glass tube, sealed the tube after letting the liquid boil for a short time, exposed it during some hours in an oil-bath to a temperature, ~~of from  $140^{\circ}$  to  $180^{\circ}$~~ , opened it after cooling so far as to be able to introduce a little potassium, sealed it again, and heated it once more to from  $160^{\circ}$  to  $180^{\circ}$  during one hour. The tube was then again opened, and, by means of a cork, connected with a glass tube, which led into a receiver, kept cold by a frigorific mixture. The contents of the tube in which the decomposition was effected, were then subjected to distillation in a water-bath, at a temperature not exceeding  $80^{\circ}$ ; when nothing farther passed over at this temperature, the remaining liquid was distilled by the heat of a spirit-lamp.

The less volatile distillate obtained in the latter way, was colourless, and of a peculiar, penetrating odour; potassium suffered no change in it; on being rectified the greater portion passed over at  $155^{\circ}$ . The body distilled over at this temperature possesses the composition  $C_{10}H_{11}$ ; its vapour has the spec. grav.  $4.8989$  (calculated for the formula  $C_{10}H_{11}$  and a condensation to 2 vols. =  $4.9062$ ); Frankland considers it to be *amyl*. Amyl is a transparent liquid of a feeble ethereal odour and a burning taste, it has a spec. grav. of  $0.7704$  at  $11^{\circ}$ , boils at  $728^{\text{mm}}$  barometer at  $155^{\circ}$ , and becomes thick and oily, but not solid, at  $-30^{\circ}$ . It cannot be inflamed at the ordinary temperature, its vapour burns with a white smoky flame; it is insoluble in water, miscible in every proportion with alcohol and with ether. It is not attacked by fuming sulphuric acid, and is but slowly, and then only at the boiling heat, oxydized by fuming nitric acid, or by a mixture of nitric and sulphuric acids, the odour of valeric acid being given off. Frankland intends to describe at a future period more minutely the products of this reaction, and also those of the

Iodide of  
amyl.

action of chlorine and bromine on the products of decomposition of iodide of amyl by zinc.

The more volatile liquid which after the decomposition is effected can be distilled over at a temperature not exceeding  $80^{\circ}$ , has a strong and disagreeable odour; it has at first a sweet, and then a tar-like taste, and boils even by the heat of the hand. It is a mixture of two liquids. If a ball of coke, saturated with fuming sulphuric acid, be introduced into its vapour (which possessed a spec. grav. of 2.42), 46.8 per cent by volume of the vapour are absorbed, and what is left is condensed, only when cooled to a temperature very near to the ordinary one. The mixture consists, according to Frankland, of liquids possessing the empirical formulæ  $C_5H_5$  and  $C_5H_6$ , formed by decomposition of part of the isolated amyl  $C_{10}H_{11}$ ; just as in the decomposition of iodide of ethyl by zinc (1) part of the ethyl  $C_2H_5$  splits into  $C_2H_2$  and  $C_2O_3$ . This view is corroborated by the fact that the spec. grav. of a mixture of the vapours of  $C_5H_5$  (absorbable by fuming sulphuric acid) and of  $C_5H_6$  (assuming a condensation to 2 vols. for both formulæ), in the above proportion, is calculated to be 2.45 (found 2.42). By the action of a mixture of anhydrous ~~anhydrous~~ sulphuric acid on the mixture of both fluids, cooled down to  $-10^{\circ}$ , the volume of the latter remained apparently unchanged, but on being distilled in a gently heated water-bath only one half of it passed over, and the distillate, after being digested with caustic potassa, possessed the composition  $C_5H_6$ , the density of its vapour = 2.4657 ( $C_5H_6$  requires for a condensation to 2 vols. the calculated density 2.4876), in the liquid state it has a spec. grav. of 0.6385 at  $14^{\circ}2$ , and the boiling-point  $30^{\circ}$  at 734<sup>mm</sup> barometer.

Frankland doubles the formulæ of both these more volatile products of decomposition of iodide of amyl by zinc, making them  $C_{10}H_{12}$  and  $C_{10}H_{10}$ . He found the former to be likewise formed on heating iodide of amyl in a sealed tube to  $140^{\circ}$  with an equal volume of water and zinc; if, after the decomposition is completed, the tube be connected with a distilling apparatus and heated to  $60^{\circ}$ , oxy-iodide of zinc, water and some undecomposed iodide of amyl remain behind, and a fluid distils over, which, after digestion with hydrated potassa and rectification, proves to be identical with the one described above, obtained by the action of zinc on iodide of amyl *without* water, possessing the composition  $C_5H_6$  or  $C_{10}H_{12}$ , boiling at  $30^{\circ}$ , 758<sup>mm</sup> barometer, and having a spec. grav. in the liquid state of 0.6413 at  $11^{\circ}2$ , and as vapour 2.4998. Frankland considers the true composition of this substance to be  $C_{10}H_{11}$ ,  $H$ , and terms it accordingly *hydride of amyl*; it has an agreeable odour, similar to that of chloroform, is insoluble in water, soluble in alcohol and ether, is separated from the alcoholic solution by water, remains fluid at  $-24^{\circ}$ , is not attacked by

fuming sulphuric acid, and is, generally speaking, a very constant compound; its vapour burns with a brilliant smokeless flame. Frankland thinks that this body is contained in the liquid described by Reichenbach(1) as *eupione*, and obtained from wood-tar, and that generally the gases disengaged by the dry distillation of wood and coal are members of the series  $\text{CH}_{n+2}$ .

Iodide of amyl.

The body which forms with the hydride of amyl the mixture of volatile products of decomposition by the action of zinc on iodide of amyl in the absence of water, and the composition of which may be expressed by the empirical formula  $\text{C}_5\text{H}_5$ , is termed by Frankland *valerene*(2), and the rational formula  $\text{C}_{10}\text{H}_{10}$  assigned to it. It is a colourless liquid of a penetrating disagreeable odour, boiling at about  $35^\circ$ , and is rapidly absorbed by anhydrous sulphuric acid and pentachloride of antimony; it was not obtained free from hydride of amyl.

Iodide of amyl yields, when decomposed by zinc in the absence of water, in addition to amyl ( $\text{C}_{10}\text{H}_{11}$ ), hydride of amyl ( $\text{C}_{10}\text{H}_{12}$ ) and valerene ( $\text{C}_{10}\text{H}_{10}$ ), also zinc-amyl ( $\text{C}_{10}\text{H}_{11}\text{Zn}$ ), the deportment of which is similar to that of zinc-ethyl and zinc-methyl(3).—When potassium is heated to its fusing-point with iodide of amyl, the same products of decomposition are formed, with the exception of the compound corresponding to zinc-amyl. The decomposition with potassium, however, cannot be recommended for the preparation of amyl.—In the presence of water, the decomposition of iodide of amyl by zinc takes place according to the equation:  $\text{C}_{10}\text{H}_{11}\text{I} + 2 \text{Zn} + \text{H}_2\text{O} = \text{C}_{10}\text{H}_{12} + \text{ZnO}, \text{ZnI}$ .

**Sulphamylic Acid.**—Kekulé(4) has subjected to a closer investigation the sulphamylic acid discovered by Cahours(5). It is formed by the mixture of equal parts of hydrated oxide of amyl and hydrated sulphuric acid without application of heat, but after standing for a longer period; the formation is complete when the liquid is perfectly miscible with water; an excess of sulphuric acid does not decompose the acid formed. By neutralizing the liquid with carbonate of baryta, protoxide of lead or lime, filtering and crystallizing the filtrate, the sulphamylates of these bases are obtained, and from these the free acid and the other salts.—The free acid isolated from the baryta-salt by means of sulphuric acid, or better, from the lead-salt by means of sulphuretted hydrogen, formed, on careful evapo-

(1) Schweigger-Seidel's Journal LXVIII, 117; Ann. Ch. Pharm. VIII, 217.

(2) Gerhardt (Laur. and Gerh. C. R. 1850, 158) considers Frankland's valerene to be identical with Balard's hydrocarbon from hydrated oxide of amyl (Ann. Ch. Phys. [3] XII, 321), which Gerhardt termed *paramylene*. Compare, also, page 329.

(3) Annual Report for 1849, III, 288.

(4) Ann. Ch. Pharm. LXXV, 275.

(5) Ann. Ch. Phys. [2] LXX, 81; Berzelius' Jahresber. XX, 516.



Sulphamy-  
lic acid.

ration of the aqueous solution, a liquid of the consistence of a thin syrup; it could not be obtained in a crystalline form. It has an acid taste and a very acid reaction; it dissolves iron and zinc with disengagement of hydrogen, is readily decomposed when exposed to the air, when heated, and *in vacuo*, and the more rapidly the more concentrated it is. It forms only neutral salts, with the exception of a basic lead-salt; the former are mostly crystallizable, all of them soluble in water, most of them in alcohol, and some also in ether; they have a more or less bitter taste, are fatty and soapy to the touch, and are decomposed in the air, when crystallized as well as when dissolved, hydrate of oxide of amyl and a sulphate being formed; they can be dried at  $100^{\circ}$ , and when heated to a higher degree they disengage an inflammable gas, and leave behind a residue of sulphate, mostly carbonaceous (see p. 329).—The *ammonia-salt* was prepared by decomposing the lime-salt with carbonate of ammonia; it forms white crystalline mass when the solution is rapidly evaporated, and when slowly white scales; its composition is  $C_{10}H_{11}O, NH_4O, 2 SO_3$ ; it does not decrease in weight at  $100^{\circ}$ , is decomposed at  $140^{\circ}$ , and burns, leaving a residue of charcoal behind.—The *potassa-salt* forms a white mammillated mass when the solution is rapidly evaporated, and mammillated groups of needles, of a silky lustre, when it is left to evaporate spontaneously; it is  $C_{10}H_{11}O, KO, 2 SO_3 + 2 HO$ ;  $HO$  escapes *in vacuo* and at  $100^{\circ}$ .—The *soda-salt* forms white or colourless mammillæ,  $C_{10}H_{11}O, NaO, 2 SO_3 + 3 HO$ , which become soft at  $35^{\circ}$ , melt at a higher temperature, and lose their water *in vacuo* and at  $100^{\circ}$ .—The *baryta-salt* forms large rhombic tables,  $C_{10}H_{11}O, BaO, 2 SO_3 + 2 HO$ ; the water escapes *in vacuo*, and the salt is decomposed at  $95^{\circ}$ .—The *strontia-salt* forms crystalline mammillæ, also containing 2 equivs. of water.—The *lime-salt* forms small colourless crystals, grouped in mammillæ,  $C_{10}H_{11}O, CaO, 2 SO_3 + 2 HO$ ; it effloresces in dry air, and is slightly decomposed when protractedly heated to  $100^{\circ}$ .—The *magnesia-salt* forms leaves of the lustre of mother-of-pearl, the salt of protoxide of manganese colourless, that of protoxide of copper pale blue flat crystals; all contain 4 equivs. of water of crystallization.—By dissolving hydrate of alumina in the aqueous acid a colourless acid liquid was obtained, which, *in vacuo* over sulphuric acid, dried up to a gelatinous, deliquescent, readily decomposing mass.—The *zinc-salt* forms tables of the lustre of mother-of-pearl, the salt of protoxide of nickel green tables, grouped in a mammillated form; both contain 2 equivs. of water of crystallization, the former is decomposed at  $110^{\circ}$ , the latter is deliquescent in moist air.—The *lead-salt* is prepared by saturating the acid with carbonate of lead, and carefully evaporating the acid liquor, towards the end over sulphuric acid; it forms small colourless crystals, grouped in mammillæ, and is  $C_{10}H_{11}O, PbO, 2 SO_3 + HO$ ; on digesting the solution of this salt with protoxide of lead, a colourless neutral liquid is obtained, from which small crystals se-

parate, containing for 1 equiv. of oxide of amyl 2 equivs. of protoxide of lead; their solution is decomposed even by the carbonic acid of the air.—By dissolving *iron* in the aqueous acid a pale-green liquor is obtained, containing protoxide of iron; on being evaporated, it deposits, first sesquioxide of iron, then small pale-green crystalline grains which rapidly assume a yellow colour in the air; by dissolving hydrated sesquioxide of iron in aqueous acid, a yellow fluid is formed, yielding on evaporation small, yellow, deliquescent, crystalline grains which are readily decomposed.—On evaporating the solution of oxide of silver in aqueous acid, the *silver-salt* separates in the form of small colourless scales which are anhydrous when dried *in vacuo*; they are blackened in contact with the air, and undergo decomposition.—By dissolving protoxide of mercury in the aqueous acid a yellow liquor is obtained which, when evaporated *in vacuo*, yields dark-yellow mammillated crystals, containing 2 equivs. of water of crystallization, and deliquescent in moist air.

Sulphamy-  
lic acid.

The decomposition of the sulphonylates by heat has been more closely examined by Kekulé in the case of the lime-salt. Above 100° this salt became soft, disengaged an inflammable gas mixed with a considerable quantity of sulphurous and carbonic acid, and blackened; the mixture of the gases was passed through milk of lime, and that portion which was not absorbed collected over water, when a colourless, volatile, inflammable liquor, floating on the water, was condensed. The quantity of the latter diminished as the heat in the retort increased; then, however, a large quantity of a yellow, less volatile liquid passed over, floating on the water of the interposed receiver; at a still higher temperature sulphur passed over, and the quantity of carbonic acid increased; sulphate of lime and charcoal remaining in the retort. The more volatile liquid, purified by washing with water and some carbonate of soda, and dried over chloride of calcium, exhibited a constant boiling-point at 42°; its composition corresponded very closely to the formula  $C_{10}H_{10}$ , the spec. grav. of its vapour was found to be 2.43 (calculated for a condensation of  $C_{10}H_{10}$  to 4 vols. it is 2.45); this substance appears, accordingly, to be identical with the most volatile of the products obtained by Balard(1) on distilling hydrated oxide of amyl with chloride of zinc, and which he termed *amylene*. The less volatile liquor did not exhibit a constant boiling-point, and was partially decomposed by each distillation; after repeated fractional distillation, that portion which distilled over between 165° and 175° was examined, and found to possess a composition approaching to the formula  $C_{10}H_{11}O$ ; it was dissolved by sulphuric acid with a red colour, like the substance obtained by

(1) Ann. Ch. Phys. [3] XII, 320; Berzelius' Jahresber. XXV, 783; compare page 327.

Hypo-  
sulphamy-  
lic acid

Gaulthier de Claubry(1) and by Rieckher(2), and termed by them oxide of amyl, it also possessed a similar composition and boiling-point.

**Hyposulphamylic Acid.**—Gerathewohl and Erdmann obtained the so-called sulphamylic acid as a product of decomposition of amyl-mercaptane by nitric acid, and O. Henry, Jun. as a product of decomposition of bisulphide of amyl or sulphocyanide of amyl by the same acid, they ascribed to its baryta-salt the formula  $\text{BaO}, \text{C}_{10}\text{H}_{11}\text{S}_2\text{O}_4 + \text{HO}$ . A W Hofmann(3) expressed the opinion that this acid might be identical with hypsulphamylic acid as obtained by Medlock by the action of nitric acid on sulphocyanide of amyl, the baryta-salt of which had the composition  $\text{BaO}, \text{C}_{10}\text{H}_{11}\text{S}_2\text{O}_5$ . J. Danson(4) has now found that the acid formed from bisulphide of amyl by nitric acid is actually hypsulphamylic acid, and yields a baryta-salt =  $\text{BaO}, \text{C}_{10}\text{H}_{11}\text{S}_2\text{O}_7$ .

**Volatile Oils in General.**—Van Nces(5) has determined the spec. grav. of a large number of volatile oils, partly prepared by himself, partly occurring in commerce. We give here only the determinations obtained with the former, along with the temperature.

|               |             |    |                 |             |     |
|---------------|-------------|----|-----------------|-------------|-----|
| Ol Absinthii  | 0 937       | 2  | Ol Cubebar      | 0 920—0 936 | 2   |
| „ Anisi stell | 0 976       | 20 | „ Lamiuli       | 0 968       | 20° |
| „ „ vulg      | 0 977—0 990 | 20 | „ Juniperi bacc | 0 862—0 875 | 2   |
| „ Calami arom | 0 950—0 956 | 15 | „ Lavendulæ     | 0 892       | 2   |
| „ Carvi       | 0 900—0 926 | 2  | „ Menth germ    | 0 908       | 20  |
| „ Carvophyll  | 1 033—1 043 | 2  | „ Petræ rect    | 0 755       | 20  |
| „ „ stip      | 1 049       | 21 | „ Succini rect  | 0 910—0 936 | 20  |
| „ Cassia flor | 1 023       | 20 | „ Valerianæ     | 0 940—0 952 | 20  |
| „ Cinn Cass   | 1 033 1 038 | 20 |                 |             |     |

Scharling(6) recommends for the preparation of essential oils the application of over-heated steam

Hartung-Schwarzkopf(7) has made some communications on the adulteration of oil of lavender with oil of turpentin, and of oil of cassia with alcohol. Observations on peppermint-oil, especially on the adulteration of that from America, have been communicated by Sandroek(8).

**Oil of Bitter Almonds.**—Laurent and Gerhardt(9) have produced

(1) Ann Ch Pharm XLIV, 128

(2) Annual Report for 1847 and 1848, J 15

(3) Annual Report for 1849, III, 296

(5) Arch Pharm [2] LXI, 18

(7) Arch Pharm [2] LXIII, 135

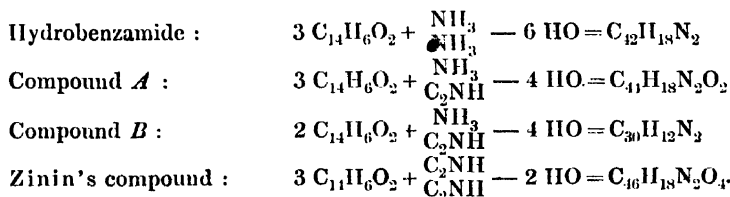
(9) Laur. and Gerh C R 1850, 113, Ann Ch Pharm LXXVI, 302 (in abstr), Compt Rend XXX, 404 (partly in abstr), Inst 1850, 114

(4) Chem Soc Qu J III, 158

(6) Loc cit page 275

(8) Arch Pharm [2] LXI, 156

some new compounds from oil of bitter almonds. Their investigations relate more particularly to the action of ammonia on oil of bitter almonds, which had already been examined by Laurent(1), and they correct the former statements in several points. They saturated oil of bitter almonds, heated to  $100^{\circ}$ , with dry ammoniacal gas, and then dissolved it in a mixture of alcohol and ether; the crystalline mass which separated after a few days, was treated with boiling alcohol, when a white powder *B* remained behind; the solution thus formed deposited, on cooling and evaporation, a body *A* in small needles. The latter, when purified by washing with a little ether to which some alcohol had been added, and recrystallizing from boiling alcohol, possesses the composition  $C_{44}H_{18}N_2O_2$ ; it melts easily and solidifies again into a resinous mass; it is insoluble in water, little soluble in cold alcohol, and readily soluble in ether. This compound is not decomposed by dilute acids when cold, but on boiling it with hydrochloric acid, oil of bitter almonds is separated and hydrocyanic acid given off. The same compound was formed by the protracted action of an alcoholic solution of cyanide of ammonium on pure oil of bitter almonds. Laurent and Gerhardt are of opinion, that the substance formerly designated as *benzhydramide*(2) is identical with this compound.—The body *B*, almost insoluble in boiling alcohol, they say is identical with *benzoylazotide*(3) and its true composition  $C_{30}H_{12}N_2$ .—With these compounds, Laurent and Gerhardt associate the *hydrobenzamide*(4),  $C_{42}H_{18}N_2$ , and the body  $C_{46}H_{18}N_2O_4$  obtained by Zinin(5) by the action of hydrocyanic acid on oil of bitter almonds (they consider Laurent's *benzimide*(6) as being identical with it), and give the following table for the formation of these substances:



On mixing nearly equal volumes of aniline and pure oil of bitter almonds (both anhydrous) and heating, water is eliminated, and the product, when left to itself (or when poured into water), solidifies to a crystalline mass which, after being pressed, is rendered pure by recrystallization from boiling alcohol or by distillation. This compound, *benzoylanilide*, is insoluble in water, very soluble in alcohol

(1) Ann. Ch. Phys. [2] LIX, 397; LXII, 23; LXVI, 181; Berzelius' Jahresber. XVI, 245; XVII, 289; XVIII, 319.

(2) Berzelius, Jahresber. XVIII, 352. (3) Ibid. 353. (4) Ibid. XVII, 291.

(5) Ann. Pharm. XXXIV, 188; Berzelius' Jahresber. XXI, 356.

(6) Berzelius' Jahresber. XVI, 246.

Oil of  
bitter  
almonds.

and ether, possesses neither taste nor odour, is easily fusible, and boils at a very high temperature without undergoing decomposition; its composition is  $C_{26}H_{11}N$ , and its formation is explained by the equation  $C_{14}H_6O_2 + C_{12}H_7N = C_{26}H_{11}N + 2HO$ . In contact with acetic or hydrochloric acids, the benzoylanilide becomes fluid. By concentrated sulphuric acid it is dissolved when heated, and water separates oil of bitter almonds from the solution, whilst it dissolves sulphate of aniline; fuming sulphuric acid decomposes it in a corresponding manner. By bromine it is rapidly decomposed when in an alcoholic solution; if the liquor be left to itself, *tribromaniline*,  $C_{12}H_4Br_3N$ , crystallizes.

On mixing 5 parts of powdered urea with 2 parts of oil of bitter almonds and heating the pasty mass (but not to  $100^\circ$ ), solution first takes place, and then the mass suddenly solidifies. The product is powdered, washed with ether, boiled with a large quantity of water and dried at  $120^\circ$ . The compound thus obtained, *benzoylureide*(1), is a white, crystalline powder, insoluble in water and ether, soluble in alcohol, and of the composition  $C_{50}H_{28}N_8O_8$ ; its formation is explained by the equation  $3C_{14}H_6O_2 + 4C_2H_4N_2O_2 = C_{50}H_{28}N_8O_8 + 6HO$ . Benzoylureide is decomposed when heated with dilute acids, oil of bitter almonds and urea being formed. Heated by itself it becomes yellow at  $170^\circ$ , and at a higher temperature disengages oil of bitter almonds and ammoniacal water, leaving behind a residue insoluble in alcohol and ether, which disappears on the application of a higher heat; it is dissolved when protractedly boiled with potassa, whilst ammonia and oil of bitter almonds escape, and the residue appears to contain benzoate of potassa.

Oil of bitter almonds is, with difficulty, converted completely into chloride of benzoyl by the action of chlorine; from a partly saturated oil, brilliant, colourless leaves were gradually deposited, which, moistened with cold alcohol and pressed, exhibited the composition  $C_{28}H_{11}ClO_4 = C_{14}H_6O_2, C_{14}H_5ClO_2$ . This combination of oil of bitter almonds and chloride of benzoyl is without odour when dry; when moist it emits acid vapours and the odour of bitter almonds; it is easily fusible, and remains liquid for a long time when carefully melted, but solidifies afterwards into a crystalline mass, which change is effected instantaneously on being touched with a glass rod. Exposed to a higher heat, it splits into chloride of benzoyl and oil of bitter almonds. Cold water scarcely acts upon the crystallized compound, but when heated with water it is decomposed into benzoic acid, oil of bitter almonds and hydrochloric acid. It is isomeric with the chloride

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(1) Laurent and Gerhardt assign the name of *ureides* to compounds which contain the elements of a salt-like urea-compound minus water. They attempted in vain to prepare a benzureide analogous to benzamide, by the action of chloride of benzoyl on urea; on gently heating both substances, some benzoylureide was formed.

benzile which Cahours(1) prepared by the action of chloride of phosphorus upon benzoic acid.

Oil of  
bitter  
almond

Laurent(2) proposes the formula  $C_{20}H_9NS_2$  for the body which Quadrat(3) obtained from the so-called sulphocyanide of benzoyl,  $C_{16}H_5NS_2$ , by boiling it with alcohol, and which he considered to be  $C_{56}H_{24}N_2S_5$  ( $C_{16}H_5NS_2 + C_4H_6O_2 = C_{20}H_9NS_2 + 2 HO$ ). We have to refer to the original concerning the suppositions of Laurent on the constitution of the other substances formed in the preparation and decomposition of sulphocyanide of benzoyl.

*Azosulfure de benzène*(4) has, according to Laurent(5), the formula  $C_{42}H_{19}NS_2$ , in accordance with a recent determination of the nitrogen, and not  $C_{126}H_{54}N_2S_{12}$  formerly ascribed to it.

**Mustard-Oil.**—Laurent(6) has published observations on the constitution of the essential oil of mustard and the compounds derived from it; they cannot well be rendered intelligible in an abstract, and we have therefore to refer to the places quoted below.

By the oxydation of the essential oil of mustard with chromic acid Illasiwetz(7) obtained a considerable quantity of acetic acid, but only a very small quantity of propionic acid; with nitric acid a tolerable amount of formic acid (besides, as already known, oxalic acid; garlic-oil yielded with nitric acid the same acids).—When mustard-oil is protractedly boiled with solution of caustic soda, in such a manner that the vapour is condensed and flows back again, and the remainder of the sulphur is then removed by means of a warm solution of protoxide of lead in potassa, the oil washed with dilute sulphuric acid and water, and lastly rectified, a colourless oil of fishy smell is obtained; the same oil is formed when mustard-oil is treated with soda-lime; Illasiwetz ascribes to this oil the formula  $6 C_6H_5O_2 + HO$ . The remaining alkaline liquor contains traces of propionic acid, sulphide of sodium, and carbonate of soda; during the action of the solution of soda on mustard-oil ammonia is said to escape.—From mustard-oil of another source Illasiwetz obtained, by boiling with solution of soda, an oil of the odour and composition of sage-oil (found 80.0 per cent of carbon, 11.1 of hydrogen, 8.9 of oxygen).

**Hydrocarbons in Crude Wood-Spirit.**—Cahours(8) has investigated the hydrocarbons in crude wood-spirit. On adding water to it a pale yellow liquor separates, floating on the surface; its

(1) Annual Report for 1847 and 1848, I, 412.

(2) Laur. and Gerh. C. R. 1850, 86.

(3) Annual Report for 1849, III, 298.

(4) The former *hydrure de sulfazobenzole*; comp. Berzelius' Jahresber. XXII, 328.

(5) Compt. Rend. XXXI, 352; J. Pr. Chem. LI, 243.

(6) Laur. and Gerh. C. R. 1850, 81; Compt. Rend. XXX, 126.

(7) Loc. cit. page 268.

(8) Compt. Rend. XXX, 319; Instit. 1850, 149; Chem. Soc. Qu. J. III, 183.

Hydrocarbons in crude wood-spirit.

boiling-point gradually rises from  $90^{\circ}$  to  $200^{\circ}$ , and it appears impossible to separate it into its various constituents by fractional distillation. On shaking this liquor with concentrated sulphuric acid a brownish-red tough mass is obtained, upon which a clear liquor, of aromatic odour, floats; the latter, washed with alkaline water, dried with fused chloride of calcium, and distilled over anhydrous phosphoric acid, exhibits a boiling-point, also rising from  $108^{\circ}$  to  $170^{\circ}$ , but at certain temperatures larger quantities distil; thus, between  $108^{\circ}$  and  $112^{\circ}$ , between  $128^{\circ}$  and  $130^{\circ}$ , between  $145^{\circ}$  and  $148^{\circ}$ , and between  $161^{\circ}$  and  $168^{\circ}$ .—The portion passing over between  $108^{\circ}$  and  $112^{\circ}$  is *toluol* (Cahours terms it *toluene*),  $C_{14}H_8$ ; the density of its vapour was found to be 3.27. Cahours prepared from it, by the action of fuming nitric acid, *nitro-toluol* and *dinitrotoluol*; and from the former, by means of sulphide of ammonium, *toluidine*. From the dinitrotoluol he obtained in a like manner the base *nitrotoluidine*, already announced by him on a former occasion(1),  $C_{11}H_8N_2O_4 = C_{11}H_8(NO_2)_2N$ ; it crystallizes in yellow needles, and forms with acids salts of which Cahours analyzed the hydrochlorate  $C_{11}H_8N_2O_4 \cdot HCl$ , the nitrate  $C_{11}H_8N_2O_6$ ,  $HIO$ ,  $NO_6$ , and the sulphate  $C_{11}H_8N_2O_6 \cdot HIO$ ,  $SO_3$ ; treated with chloride of benzoyl or chloride of cumyl, it yields compounds analogous to the amides and anilides.—The portion distilling between  $128^{\circ}$  and  $130^{\circ}$ , is *xylol* (Cahours terms it *xylene*) has the composition  $C_{16}H_{10}$ , and yields, with fuming nitric acid, similar nitro-compounds. Nitroxylol, dissolved in alcohol, gives, with sulphide of ammonium, a base analogous to toluidine, viz.: *xylidine*.—The portion distilling between  $145^{\circ}$  and  $148^{\circ}$  contains *cumol* (Cahours terms it *cumene*),  $C_{18}H_{12}$ , from which Cahours prepared *nitrocumol* and *dinitrocumol*, *cumidine* and *nitrocumidine*.—A. W. Hofmann(2) had established the formula  $C_{18}H_{12}$  for mesitol; it is, accordingly, isomeric with cumol. Cahours has made a fresh determination of the density of the vapour of mesitol, and found it to correspond to a condensation of  $C_{18}H_{12}$  to 4 vols.(3) Besides the products of substitution of mesitol, hitherto known(4),  $C_{18}H_{10}(NO_2)_2$  and  $C_{18}H_9(NO_2)_3$ , Cahours prepared also nitromesitol,  $C_{18}H_{11}(NO_2)$ , which confirms Hofmann's formula; the latter substance is obtained from mesitol by means of fuming nitric acid, when an excess of the acid is avoided, and the substances acting upon each other are carefully cooled. On treating nitromesitol with an alcoholic solution of potassa, the temperature rises and a liquid volatilizes along with another substance, which crystallizes on spontaneous evaporation from its solution in alcohol in fine tables, possessing the same composition as nitromesitol.—The portion distilling at

(1) Annual Report for 1849, III, 278.

(2) Ibid. 306.

(3) He found it, (the details see Chem. Soc. Qu. J. III, 17; Ann. Ch. Pharm. LXXIV, 106) 4.35 at  $236^{\circ}$ , 4.28 at  $250^{\circ}$ ; calculated 4.15.

(4) Annual Report for 1849, III, 306.

from 164° to 168° possesses the same composition and density of vapour as cumol and mesitolol, but differs from both these substances. —Cahours points out that here, amongst the products of the dry distillation of wood, hydrocarbons of the same kind are found as those obtained by Mansfield(1) in coal-tar.—From some sorts of wood-spirit of commerce he obtained a more volatile oily liquid, boiling at 58° to 100°, which consisted chiefly of acetate of oxide of methyl and of Fremy's metacetone ( $C_{12}H_{10}O_2$ ). Schist.-oil.

**Schist.-Oil.**—In an investigation of bituminous slate, Delahaye(2) made also some communications on the volatile oil which can be obtained from it by distillation. From the oil, freed from tar by one rectification, an oil is obtained by a second rectification, which passes over at 85°; it is similar to naphtha, of a spec. grav. 0.753 at 15°, and contains 85.7 per cent of carbon, and 14.3 per cent of hydrogen. When the temperature rises, the quantity distilling over decreases, until again, between 130° and 140°, an oil passes over similar to *eupione*, of a spec. grav. 0.800, and containing 86.3 per cent of carbon, and 13.9 of hydrogen; between 230° and 250°, an oil distils of the spec. grav. 0.820; at 300°, another, containing much paraffin, of the spec. grav. 0.90 or 0.91; between 320° and 360°, an oil of the spec. grav. 0.91 or 0.93, which becomes solid when cold, and cannot be distilled without undergoing decomposition.

**Amber-Oil.**—Marsson(3) obtained, on rectifying crude amber-oil, which he had himself prepared by dry distillation of amber without sulphuric acid, a pale-yellow liquid, of a slightly acid reaction, and a spec. grav. of 0.8841 at 15°; this was again rectified, after being digested with powdered quicklime for eight days. The portion which distilled over first was neutral, almost colourless, of 0.8013 spec. grav., and gave, by combustion with chromate of lead, 86.58 and 86.76 per cent of carbon, 11.64 and 11.75 per cent of hydrogen. The difference between the sum of these constituents and 100 is ascribed by Marsson to the difficulty with which a complete combustion of the amber-oil is effected. According to him, crude amber-oil contains volatile acids; on distilling it with water, he found (by saturating with baryta-water, converting the baryta-salts into ammonia-salts, and these again into silver salts, and separating the latter by partial crystallization) that it contained butyric, propionic, and acetic acids, and in one instance probably also valeric and caproic acids.

**Propylene and its Homologues.**—Reynolds(4) has now published a more detailed account of his experiments (already quoted in last year's

(1) Annual Report for 1847 and 1848, II, 35.

(2) Rev. Scientif. Industr. XXXVIII, 161; Annual Report for 1849, III, 307, concerning St. Evre's statements.

(3) Arch. Pharm. [2] LXII, 1.

(4) Chem. Soc. Qu. J. III, 111; Ann. Ch. Pharm. LXXVII, 114.



Propylene  
and its  
homo-  
logues.

Report, p. 294) on the decomposition of hydrated oxide of amyl by heat. On passing the vapour of hydrate of oxide of amyl through a long red-hot glass tube, a liquid (apparently unchanged hydrated oxide of amyl) and a gas are obtained; when the heat is too low, but little gas is formed; when too high, almost exclusively marsh-gas: when the temperature is, however, properly regulated, a gas is obtained which burns with a bright flame, and about one-half of which consists of a hydrocarbon  $C_6H_6$ , termed by Reynolds(1) *propylene* (formerly '*metacetene*'): the remainder consists, as it appears, chiefly of 'marsh-gas'. To this gaseous mixture bromine was added in small quantities, until the latter was no farther decolorized (by passing the gas into an excess of bromine, a large quantity of products of substitution are formed). The oily liquid obtained was washed with water, dried over chloride of calcium, and repeatedly rectified over quicklime. Its boiling-point was at first  $136^\circ$ , rose rapidly to  $143^\circ$ , where it remained constant for a pretty long time, and then slowly to  $160^\circ$ , when the remaining brown liquid was decomposed, with disengagement of hydrobromic acid. By repeatedly rectifying the distillate, a colourless oil was obtained, not congealing at  $-20^\circ$ , boiling at  $143^\circ$ , and possessing an ethereal odour slightly resembling that of garlic, and a spec. grav. of 1.7. Its composition is  $C_6H_5Br$ , or  $C_3H_5Br + HBr$ , *hydrobromate of bromide propionyl*(2): the density of its vapour was found to be 7.3 (calculation gives 7.0 for a condensation of  $C_6H_5Br_2$  to 4 vols.) This compound is decomposed by concentrated sulphuric acid: when digested with an alcoholic solution of potassa, a violent reaction ensues, and bromide of potassium is deposited, whilst a liquid distils over from which, on addition of water, a heavy, colourless, very mobile, volatile liquid is separated, of the odour peculiar to rancid fishes. The latter does not exhibit a constant boiling-point, after being dried over chloride of calcium, and rectified over quicklime. The portion passing over between  $45^\circ$  and  $56^\circ$  contains 29.1 per cent of carbon, and 4.0 of hydrogen (approximately corresponding to  $C_6H_5Br$ ): that passing over between  $56^\circ$  and  $60^\circ$ , 29.3 and 4.2; and that between  $60^\circ$  and  $70^\circ$ , 30.9 and 4.6.—By the action of chlorine on the gas formed in the decomposition of the hydrated oxide of amyl, an oily liquid was obtained which, dried over chloride of calcium, and repeatedly rectified over quicklime, boiled between  $100^\circ$  and  $103^\circ$ , and possessed the composition  $C_6H_6Cl_2$ . With alcoholic solution of potassa, this substance is decomposed like the corresponding bromine-compound.

Calours(3) has also made investigations on the action of chlorine

(1) Regarding the formation of propylene, compare also pages 270 and 273.

(2) Regarding this body, see also pages 270 and 273.

(3) Compt. Rend. XXXI, 291; J. Pr. Chem. LI, 249.

and bromine on propylene, and the hydrocarbons homologous to it. He prepared propylene by decomposing pelargonic, ethallic, or a homologous acid by heat(1). If the gas disengaged in this decomposition be prepared propylene by decomposing pelargonic, ethallic, or a homologous brought in contact with chlorine in a large flask, white vapours are immediately formed even in diffused light, and a liquid is condensed. The latter consists chiefly of the compound  $C_6H_6Cl_2$ . By the action of chlorine upon this substance, a series of compounds are formed, which are homologous to those obtained from oil of olefant gas (chloride of elayl) by the same treatment. Cahours' statements on these compounds are put together in the following tables (the formulæ are calculated for a condensation to 4 vols.; the densities of vapour observed have not been stated.)

Propylene  
and its  
homo-  
logues.

|              | Boiling-point. | Spec. grav. | Is converted, when distilled with<br>an alcoholic solution of potassa, into : |
|--------------|----------------|-------------|-------------------------------------------------------------------------------|
| $C_6H_6Cl_2$ | 104°           | 1.151       | $C_6H_5Cl$                                                                    |
| $C_6H_5Cl_3$ | 170°           | 1.347       | $C_6H_4Cl_2$                                                                  |
| $C_6H_4Cl_4$ | 195—200°       | 1.548       | $C_6H_3Cl_3$                                                                  |
| $C_6H_3Cl_5$ | 220—225°       | ?           | $C_6H_2Cl_4$                                                                  |
| $C_6H_2Cl_6$ | 240—245°       | 1.626       | $C_6HCl_5$                                                                    |
| $C_6HCl_7$   | 260°           | 1.731       | $C_6Cl_6$                                                                     |
| $C_6Cl_8$    | 280°           | 1.860       |                                                                               |

On using bromine in place of chlorine, Cahours obtained the following compounds :

|              |      |       |                                           |
|--------------|------|-------|-------------------------------------------|
| $C_6H_6Br_2$ | 145° | 1.974 | $C_6H_5Br$ ; sp. gr. 1.472 ; boil.-p. 62° |
| $C_6H_5Br_3$ | 192° | 2.336 | $C_6H_4Br_2$ " 1.950 " 120°               |
| $C_6H_4Br_4$ | 226° | 2.469 | $C_6H_3Br_3$ "                            |
| $C_6H_3Br_5$ | 255° | 2.601 |                                           |

By acting on the bromine-compound corresponding to the oil of olefant gas (bromide of elayl) first with bromine and then with alcoholic solution of potassa, Cahours attempted to obtain the compounds of bromine and carbon  $C_4Br_6$  and  $C_4Br_4$ , but without success; the derivatives of the compound  $C_4H_4Br_2$ , which are richer in bromine, form by the decomposition with alcoholic solution of potassa, in addition to bromide of potassium and a member of the other series, potassa-salts of bromine-acids, concerning which Cahours intends to publish the details at a future period. He obtained, however, the following compounds :

|              |              |
|--------------|--------------|
| $C_4H_4Br_2$ | $C_4H_3Br$   |
| $C_4H_3Br_3$ | $C_4H_2Br_2$ |
| $C_4H_2Br_4$ | $C_4HBr_3$   |
| $C_4HBr_5$   |              |

By the action of bromine on butylene, amylene, oleene, paramylene, he obtained the compounds :

|                    |                 |
|--------------------|-----------------|
| $C_8H_8Br_2$       | $C_8H_7Br$      |
| $C_{10}H_{10}Br_2$ | $C_{10}H_9Br$   |
| $C_{10}H_9Br_3$    | $C_{10}H_8Br_2$ |
| $C_{12}H_{12}Br_2$ |                 |
| $C_{16}H_{16}Br_2$ |                 |
| $C_{20}H_{20}Br_2$ |                 |

(1) Comp. page 273.

Naphtha-  
lin.

**Naphthalin.**—Laurent(1) states that, in addition to the two compounds of naphthalin and chlorine already described, viz.: bichloride of naphthalin,  $C_{20}H_8, Cl_2$ , and tetrachloride of naphthalin,  $C_{20}H_8, Cl_4$ , a third compound exists, isomeric with the tetrachloride; he terms it  *$\beta$  tetrachloride of naphthalin*. On treating naphthalin with chlorine, a thick mass is formed, containing, besides other compounds of chlorine, an oily ( $C_{20}H_8, Cl_2$ ) and a solid ( $C_{20}H_8, Cl_4$ ) compound of chlorine and naphthalin. The oily compound is extracted by means of ether, the liquid remaining is then cooled down to  $0^\circ$  for some time, when it becomes like congealed olive-oil; it is then filtered and pressed through a fine cloth, and the residue (to which the solid mass obtained by repeatedly treating the expressed liquid in the same way is added) dissolved in a little ether mixed with from  $\frac{1}{3}$  to  $\frac{1}{10}$  of alcohol; from this solution, when kept in loosely-covered vessels, a crystalline mass separates after a few days. This consists of ordinary tetrachloride of naphthalin, but little soluble in ether and still less so in alcohol, and of  *$\beta$  tetrachloride of naphthalin*, very soluble in alcohol and still more so in ether. Both are separated from each other by repeated crystallizations from alcohol and ether;  *$\beta$  tetrachloride of naphthalin* is pure when it is immediately and completely dissolved by a small quantity of ether. It crystallizes in small leaves united into masses, is colourless and odourless; when fused it may be cooled down to  $10^\circ$  without congealing; it crystallizes, however, after some time in masses of a radiated structure. Its amount of carbon and hydrogen agreed with the formula  $C_{20}H_8, Cl_4$ . When heated, or when treated with a boiling alcoholic solution of potassa, it loses 2 HCl and passes into various modifications of bichloride of naphthalin,  $C_{20}H_8, Cl_2$ . Laurent thinks that the compound formerly described by him(2) as *chlorure de chlonaphtane*, is identical with the  *$\beta$  tetrachloride of naphthalin*.—When bromine is made to act upon  *$\beta$  tetrachloride of naphthalin* during twenty-four hours in a closed vessel, the product formed, washed with luke-warm alcohol and then redissolved in boiling ether, bromochloride of naphthalin,  $C_{20}H_8, Cl_3Br$ , crystallizes, on cooling and spontaneously evaporating the solution, in the form of oblique rhombic prisms, the faces of which in the clinodiagonal principal section form an angle of  $103^\circ$ , the oblique terminal face being likewise inclined towards the faces of the prism at an angle of  $103^\circ$ . This compound is more soluble in ether than the ordinary tetrachloride of naphthalin, but less so than  *$\beta$  tetrachloride of naphthalin*.—The boiling alcoholic solution of  *$\beta$  tetrachloride of naphthalin* produces with an alcoholic solution of sulphide of ammonium, first a brown colour, then a pale yellow precipitate, the composition of which, according to Laurent, lies between that

(1) Laur. and Gerh. C. R. 1850, 1; Ann. Ch. Pharm. LXXVI, 298.

(2) Rév. Scientif. Industr. XIII, 77.

expressed by the formulæ  $C_{20}H_7Cl$ ,  $S_4$ , 2 HO and  $C_{20}H_6Cl_2$ ,  $S_4$ , 2 HO, Naphthalin. which, however, might possibly contain 2 HO more.—To the six modifications of trichloro-naphthalin already described, Laurent adds now a seventh, and terms it *Æ trichloro-naphthalin*. It is formed when the crude oil accompanying the formation of tetrachloride of chloro-naphthalin ( $C_{10}H_7Cl$ ,  $Cl_4$ ), is treated with fuming sulphuric acid; on being heated, hydrochloric acid escapes and the liquid becomes brown; water is then added and cold applied. A brown mass separates after some hours, which is first washed with water, then with very little alcohol, and dissolved in ether; on evaporating this solution, a mixture of A trichloro-naphthalin with *Æ trichloro-naphthalin* and a little oil separates, from which *Æ trichloro-naphthalin* is prepared by repeated crystallizations from ether, inasmuch as it is least soluble in this substance (in alcohol, on the contrary, *Æ trichloro-naphthalin* is more soluble). It crystallizes in small needles, derived from a prism of  $122^\circ$ , and melts at  $93^\circ$ . Laurent explains its formation by the equation:  $C_{20}H_7Cl$ ,  $Cl_4 + SO_3 = C_{20}H_5Cl_3 + SO_3 + 2 HCl$ .—Dibromonaphthalin ( $C_{20}H_6Br_2$ ) is slowly dissolved by boiling nitric acid; on adding water, after the solution is completed, an oily body, crystallizing on cooling, is precipitated, which, after repeated crystallizations from a mixture of alcohol and ether, forms bromo-dinitro-naphthalin,  $C_{20}H_5Br(NO_4)_2$ ; it is insoluble in water, readily soluble in ether, and little soluble in alcohol; when rapidly heated in a tube it is inflamed.—If naphthalin be gradually added to heated chloride of sulphur, hydrochloric acid escapes; after the action has ceased, water and ammonia are added and the liquor decanted, when a brown, soft mass remains behind. This is a mixture of sulphur and the modification (separable by boiling alcohol) of dichloro-naphthalin ( $C_{20}H_6Cl_2$ ) which Laurent describes as C dichloro-naphthalin; it crystallizes in needles of  $111^\circ$  to  $112^\circ$ , and melts at about  $51^\circ$ .—Laurent gives farther a corrected description of the crystalline form of *tetrabromide of chloro-bromo-naphthalin*,  $C_{20}H_6ClBr$ ,  $Br_4$ , and mentions, that the compound formerly termed by him *perchlorure de bronaphtèse* and viewed as  $C_{20}H_6Br_2$ ,  $Cl_5$ , possesses the same composition as tetrachloride of chloro-dibromo-naphthalin ( $C_{20}H_5Br_2Cl$ ,  $Cl_4$ ); both substances are connected with other compounds of a similar composition by isodimorphism.

Piria(1) has made investigations on the action of sulphite of ammonia on nitronaphthalin.—Naphthalin is, contrary to the usual statements, also attacked by cold nitric acid, provided this be sufficiently concentrated, and in five or six days is completely converted into very pure nitronaphthalin; for the preparation of nitronaphthalin it is

(1) Sull' Azione del Solfito d' Ammoniaca sulla Nitronaftalina, Pisa, 1850; Ann. Ch. Pharm. LXXXVIII, 31; Ann. Ch. Phys. [3] XXXI, 217; a short notice of the results Compt. Rend. XXXI, 488; J. Pr. Chem. LII, 56.

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advisable to use from 5 to 6 parts of nitric acid of commerce, spec. grav. 1.33, for 1 part by weight of naphthalin, and to stir the mixture frequently, especially at the commencement.—On dissolving 200 grms. of nitronaphthalin thus prepared and washed, in 1 kilogram. of alcohol in a large flask on the sand-bath, and then adding 1 kilogram. of a solution of sulphite of ammonia of 1.24 spec. grav. whilst the mixture is kept heated and agitated, the latter becomes first red, then yellow; on continuing to apply heat, so as to keep the mixture gently boiling, bisulphite of ammonia is separated in crystalline crusts which prevent the boiling from proceeding regularly; the acid liquor is now mixed with carbonate of ammonia until it exhibits an alkaline reaction and the separated crystals are completely redissolved, and this process is repeated as long as the liquor acquires an acid reaction on boiling; the boiling is then continued until a sample of the liquor dissolves completely in water without producing a cloudiness. In most cases the liquor divides into two layers, the upper one being an alcoholic solution of the product of decomposition of nitronaphthalin, and the lower one an aqueous solution of sulphate of ammonia and of the excess of sulphite of ammonia. The upper layer is evaporated over an open fire to the consistence of oil, which when put in a cool place, deposits orange-coloured foliated crystals after about twenty-four hours, consisting of *thionaphthamate of ammonia*, whilst the mother-liquor contains *naphthionate of ammonia* in solution.

In order to prepare *naphthionic acid*, the mother-liquor is heated to 100°, and mixed with a large excess of hydrochloric acid; sulphurous acid is given off (derived from an admixture of sulphite of ammonia) and naphthionic acid is precipitated in the form of a reddish-white crystalline powder. Naphthionic acid is freed from a certain amount of a violet, resinous substance and other impurities by repeated washings with water and with alcohol; to render it perfectly pure, it is converted into a lime- or soda-salt, from which, after repeated recrystallizations, the acid is precipitated by hydrochloric acid. Naphthionic acid precipitated, whilst cold, from one of these salts, forms a white, voluminous powder; if, however, precipitated whilst warm, it forms an aggregate of light silky crystals; it has no taste, and is odourless, reddens litmus, is scarcely soluble in cold water (1 part of acid requiring more than 2000 parts of water) or in alcohol, more so in boiling water, from which it is separated on cooling in the form of white crystalline needles. The composition of the latter is  $\text{HO}, \text{C}_{20}\text{H}_8\text{NS}_2\text{O}_5 + \text{HO}$  (1 HO escapes at 100°). Naphthionic acid is neither dissolved nor decomposed by boiling with concentrated hydrochloric acid; with concentrated sulphuric acid it forms a colourless solution, which only at a temperature exceeding 200° becomes black and disengages sulphurous acid. When heated with concentrated solution of caustic soda it is not decomposed. Oxydizing agents act readily upon it; air changes it easily, especially when moist; on this account, on

washing the acid, boiled water must be used and an extract-apparatus; chlorine causes a brown colour and separates a brown resin when passed into the solution of a naphthionate; bichromate of potassa (particularly when mixed with sulphuric acid) produces the same effect; pure and dilute nitric acid separates from the naphthionates only the acid, without decomposing the latter; when, however, the nitric acid contains nitrous acid, or when heat is applied, the naphthionic acid is decomposed with formation of brown resin. When heated by itself, naphthionic acid burns, sulphurous acid is given off along with a vapour resembling in odour the oil of bitter almonds, and a copious residue of charcoal, burning with difficulty, is left behind.

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Naphthionic acid has a great affinity for bases, it neutralizes the alkalis completely, and expels the acetic acid from the acetates. All the naphthionates are soluble, and crystallize with facility; a red colouring matter obstinately adheres to them, which cannot be removed by animal charcoal, alumina, or hydrated protoxide of lead, and from which these salts are best freed by repeated crystallizations from weak alcohol, light being excluded. The solutions of the naphthionates are opalescent like those of the acid salts of quinine (the solution of 1 part of naphthionate of soda in 200,000 parts of water exhibits this phenomenon); mineral acids precipitate from them the naphthionic acid (acetic acid does not throw it down from an aqueous solution, but partially from an alcoholic solution of naphthionate of soda). A solution of naphthionate of soda produces, with sesquichloride of iron, a copious brick-coloured precipitate, becoming brown when heated, with bichloride of platinum a pale yellow, with nitrate of silver a white, crystalline precipitate, with terechloride of gold a purple colour, with protochloride of mercury a white precipitate dissolving when heated, with sulphate of copper a yellow colour without precipitate. The dry naphthionates do not appreciably change in the air; their solutions assume a red colour under the influence of air and light; the formula of the anhydrous naphthionates is  $RO, C_{20}H_8NS_2O_5$ .—The *potassa-salt* is readily soluble in water and in alcohol, but with difficulty when a sufficiently large quantity of free potassa is present. In order to prepare it, impure naphthionic acid is diffused in a hot concentrated solution of potassa; the brown liquor deposits, on cooling, crystals of the salt which are purified by recrystallization from weak alcohol. This salt forms micaceous laminae, slightly coloured, and is anhydrous.—The *ammonia-salt* crystallizes, but with great difficulty.—The *soda-salt* is prepared by heating crude naphthionic acid and carbonate of soda with a little alcohol of 60 per cent, filtering the boiling solution and crystallizing; it is purified from a resinous substance by means of washing with a concentrated alcoholic solution of caustic soda and repeatedly crystallizing from as small a quantity of weak alcohol as possible, with the addition of some animal charcoal; the crystals

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cannot easily be obtained perfectly colourless, and contain 8 atoms of water (7 of which escape below  $100^{\circ}$ , the 8th only at  $130^{\circ}$ ); they form prisms of the monoclinometric system, and exhibit the combinations  $OP \cdot \infty P \cdot + P$  ( $\infty P : \infty P$  in the clinodiagonal principal section  $= 111^{\circ} 55'$ ,  $OP : \infty P = 118^{\circ} 56'$ ;  $OP : + P = 96^{\circ} 34'$ ,  $OP$  : principal axis  $= 51^{\circ} 17'$ ; ratio of the principal axis to the secondary axes  $= 1 : 0.76047 : 0.91382$ ). The desiccated salt in the air absorbs again its full amount of water; it is less soluble in aqueous alcohol than the hydrated salt, and when dissolved in it by continued boiling, the solution solidifies on cooling into a mass of crystals grouped like cauliflower, which, however, are gradually transformed into the monoclinometric prisms just described.—The *baryta-salt* is best prepared by dissolving naphthionate of soda and chloride of barium in a small quantity of boiling water, when it crystallizes on cooling; if it be separated from the concentrated solution whilst yet warm, it forms micaceous leaves; ~~but~~ large rhombic tables if separated from a more dilute solution after it had become quite cold. The crystals defloresce so readily that it was impossible to ascertain the difference in the amount of water probably belonging to both forms.—The *lime-salt* is purest prepared by boiling crude naphthionic acid with milk of lime, evaporating the filtrate in the water-bath, crystallizing, removing the resinous substance by washing with cold alcohol and recrystallizing from boiling water with the addition of animal charcoal. The crystals contain 8 equivs. of water (7 of which escape at  $100^{\circ}$ , the 8th only at about  $140^{\circ}$ ); they form tables of the monoclinometric system ( $OP \cdot \infty P \cdot + P$  with other subordinate faces;  $\infty P : \infty P$  in the clinodiagonal principal section  $= 117^{\circ} 4'$ ,  $OP : \infty P = 124^{\circ} 19'$ ;  $OP : + P = 120^{\circ} 30'$ ;  $OP$  : principal axis  $= 48^{\circ} 38'$ ; principal axis : clinodiagonal : orthodiagonal  $= 1 : 1.3553 : 1.6623$ ).—The *magnesia-salt* forms, on cooling the concentrated solution, long, rhombic prisms, pointed by two faces; they contain 8 equivs. of water which escape completely at  $150^{\circ}$ ; the mother-liquor of these crystals when evaporated *in vacuo*, produces large monoclinometric crystals, containing 10 atoms of water (the latter crystals exhibit  $OP \cdot \infty P \cdot \infty P \cdot + P \cdot \infty$ ;  $\infty P : \infty P$  in the clinodiagonal principal section  $= 76^{\circ} 22'$ ;  $OP : \infty P = 114^{\circ} 57'$ ;  $OP : + P \cdot \infty = 102^{\circ} 7'$ ;  $OP$  : principal axis  $= 46^{\circ} 57'$ ; principal axis : clinodiagonal : orthodiagonal  $= 1 : 0.8416 : 0.4837$ ).—The *zinc-salt* crystallizes in red rhomboidal leaves from a solution of 2 parts of naphthionate of soda and 1 part of sulphate of zinc.—From a liquor which holds in solution naphthionate of soda and acetate of lead, both salts crystallize without decomposition. When nitrate of lead is dissolved in a sufficiently concentrated hot solution of naphthionate of soda, the *lead-salt* of naphthionic acid crystallizes on cooling in the form of reddish needles. These contain 2 atoms of water; by boiling the aqueous solution this salt loses the property of crystal

lizing.—The *salt of oxide of copper* does not exist; sulphate of copper produces with naphthionate of soda a red colour, but no precipitate, and after evaporation *in vacuo* the protoxide of copper is found to be reduced to suboxide.—On mixing solutions of nitrate of silver and naphthionate of soda, the *silver-salt* is precipitated in the form of a white, light and caseous powder which sometimes is quickly transformed into heavy granular crystals; in both those states it contains 2 equivs. of water. By treating this salt with warm water and adding ammonia, a solution is formed from which the compound  $\text{AgO}, 2\text{NH}_3 + \text{C}_{20}\text{H}_8\text{NS}_2\text{O}_5 + 2\cdot\text{HO}$  in the form of greyish-white crystalline grains is separated on cooling.

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*Thionaphthamic acid*, the ammonia-salt of which is obtained in the manner described, page 340, has the same composition as naphthionic acid; it cannot be produced in the isolated state, inasmuch as it is decomposed when eliminated from its salts by other acids (even by acetic acid) into sulphuric acid and naphthalidine, which latter was first obtained by Zinin(1) by the action of sulphide of ammonium on nitronaphthalin. The thionaphthamates possess, in the anhydrous state, like the naphthionates, the composition  $\text{RO}, \text{C}_{20}\text{H}_8\text{NS}_2\text{O}_5$ ; they all are soluble and crystallizable, forming large red or amethyst-coloured leaves of pearly lustre (in a perfectly pure state they are probably colourless); their solutions rapidly assume a reddish-brown colour in the air, especially in the presence of free acids, heat and sunlight; a resinous substance, sulphuric acid and naphthalidine being formed; a very slight excess of alkali, however, prevents this decomposition. On distilling a thionaphthamate with hydrate of lime in excess, naphthalidine passes over. The *ammonia-salt*, when purified by recrystallization from boiling water, forms reddish micaceous leaves, very soluble in water and in alcohol; it is readily decomposed. By boiling it with some carbonate of potassa in excess and crystallizing, the *potassa-salt* is obtained in large leaves of a pearly lustre and anhydrous; it is easily soluble in pure water, less so when mixed with potassa, and scarcely at all in alcohol.—The *soda-salt* prepared in the same manner forms brilliant reddish leaves.—On the addition of nitrate of lead to a concentrated, boiling solution of thionaphthamate of potassa, the *lead-salt* separates on cooling in crystalline grains; when the thionaphthamate of potassa has not been in excess a double salt of nitrate and thionaphthamate of lead is precipitated. On mixing boiling solutions of thionaphthamate of potassa and of acetate of lead in excess, a double salt of thionaphthamate and acetate of lead,  $\text{PbO}, \text{C}_{20}\text{H}_8\text{NS}_2\text{O}_5 + \text{PbO}, \text{C}_4\text{H}_3\text{O}_3$ , is separated on cooling in the form of elongated, concentrically-grouped leaves.—From a mixture of hot, concentrated solutions of chloride of barium and thionaphthamate of potassa, reddish leaves of the *baryta-salt*, which contain 3 equivs. of water, separate on cooling.

(1) J. Pr. Chem. XXVII, 140; Berzelius' Jahresber. XXIII, 545.



**Piria** concludes from these experiments that nitronaphthalin is converted under the influence of sulphite of ammonia, as well as under that of sulphide of ammonium, into naphthalidine, but that in the former decomposition, the naphthalidine formed and the sulphuric acid generated by the oxydation of the sulphurous acid, give rise to two coupled acids, naphthionic and thionaphthamic acids, both of which may be represented by the formula,  $\text{HO}, \text{C}_{20}\text{H}_8\text{NS}_2\text{O}_5$ .

In order to prepare the salt of naphthalidine Piria recommends the decomposition of heated solutions of thionaphthamates by dilute sulphuric acid, when sulphate of naphthalidine crystallizes; or by hydrochloric acid in which case the liquor is boiled for a short time; the mixture of sulphate and hydrochlorate of naphthalidine which crystallizes is redissolved, and the solution deprived of its sulphuric acid by chloride of barium; thus pure hydrochlorate of naphthalidine is readily obtained. The hydrochlorate of naphthalidine thus prepared is easily changed in the air, especially when moist; when sublimed (forming light, white, crystalline flakes) it is not liable to change. Naphthalidine itself is readily obtained by distilling thionaphthamates or hydrochlorate of naphthalidine with hydrate of lime in excess.—Piria observed, farther, that naphthalidine and its salts produce blue precipitates, afterwards becoming purple, with sesquichloride of iron, terchloride of gold, nitrate of silver, and other oxydizing substances. This product of oxydation he terms *naphthamein*. In order to prepare it, hydrochlorate of naphthalidine is dissolved in alcohol, the solution diluted with water, a dilute solution of sesquichloride of iron added by drops and slightly in excess, the liquor filtered off after a few hours, the precipitate washed, first with water, then with alcohol, and lastly dried *in vacuo*; the liquor filtered off from the precipitate contains a considerable quantity of protochloride of iron and chloride of ammonium. Naphthamein thus obtained is a light, amorphous powder of a dark purple hue, resembling orcein. It fuses when heated, and is decomposed, leaving a residue of charcoal behind. It is neither soluble in water nor in alkalis, little so in alcohol, but readily in ether; it forms a blue solution, with cold concentrated sulphuric acid, and is reprecipitated from it by water; it dissolves in concentrated acetic acid with a violet colour, and is not precipitated from this solution by means of water, but by most of the acids, alkalis and salts (but not by tartaric acid). The composition of naphthamein has not, as yet, been ascertained by Piria.

On treating sulphonaphthalic acid(1) with nitric acid, nitro-sulphonaphthalic acid,  $\text{C}_{20}\text{H}_7(\text{NO}_3), 2 \text{SO}_3$ , is formed, according to Laurent(2), and from this, by the action of sulphide of ammonium, thionaphthamic acid,  $\text{C}_{20}\text{H}_7(\text{NH}_2), 2 \text{SO}_3$ . The latter may also

(1) Comp. Annual Report for 1849, III, 303.

(2) Compt. Rend. XXXI, 537; J. Pr. Chem. LII, 58

be obtained from naphthalidine-carbamide(1) ( $C_{21}H_8NO$ ); by heating it gently with concentrated sulphuric acid, carbonic acid escapes, and on the addition of water thionaphthamic acid is separated ( $2 [SO_3, HO] + C_{21}H_8NO = C_{20}H_9N, 2 SO_3 + CO_2 + H_2O$ ). By the continued action of nitric acid on sulphonaphthalic acid *dinitro-sulphonaphthalic acid* is formed, the ammonia-salt of which crystallizes in yellow needles, and possesses the composition  $NH_3 + C_{20}H_6(NO_4)_2, 2 SO_3$ ; by the action of sulphuretted hydrogen on this salt sulphur is separated and an acid formed which is probably *nitro-thionaphthamic acid*,  $C_{20}H_6(NO_4)(NH_2), 2 SO_3$ . On treating dinitronaphthalin with sulphuretted hydrogen a carmine-coloured base is formed, most likely *nitronaphthalidine*, which deflagrates when heated in closed vessels.

**Stearoptene from Oil of Cassia**—Rochleder(2) has examined a stearoptene from oil of cassia. When purified by recrystallization from alcohol it formed colourless, odourless, brittle leaves; its composition was  $C_{28}H_{10}O_5$ ; Rochleder writes it  $2 C_{14}H_7O_2 + HO$ , and terms the stearoptene *benzhydrol*. This stearoptene melts readily; exposed to a high temperature it is volatilized without boiling, and a yellow oil passes over, which soon solidifies into a yellow, foliated mass. On distilling the stearoptene with aqueous caustic potassa a heavy yellow oil passes over, of an agreeable odour, resembling that of an emulsion of sweet almonds; its composition was  $C_{42}H_{22}O_{11}$ , which Rochleder writes  $2 (C_{14}H_6O_3, H_2O) + C_{14}H_7O_2, HO$ ; a small quantity of resin remains with the potassa. The stearoptene dissolves with a yellow colour in sulphuric acid, and is reprecipitated from the solution by water. Concentrated nitric acid converts it into an acid which greatly resembles nitrobenzoic acid ( $C_{14}H_5(NO_4)O_4$ ); the amount of carbon and hydrogen it contains agrees, however, better with the formula  $C_{14}H_7(NO_4)O_6$ .

**Anemonin**.—As a contribution to our present knowledge of anemonin, and partly in contradiction to former statements, Jul. Muller(3) communicates the following facts. From the aqueous distillate of the fresh herb of *Pulsatilla pratensis*, and still better from that of *Anemone nemorosa*, anemonin is deposited, but very slowly, in crystals which are almost insoluble in pure ether, but dissolve in concentrated sulphuric acid without being blackened, even after standing for several days. According to the determination of Frankenheim, the crystals of anemonin are rhombic; ratio of the axes of the type: macrodiagonal brachydiagonal principal axis =  $1.0 : 1.777 : 0.409$ ; the combinations amongst others,  $\infty P. \infty \bar{P} \infty. \infty \check{P} \infty. \bar{P} \infty. \check{P} \infty (\bar{P} \infty. \infty \bar{P} \infty = 130^\circ 34'; \check{P} \infty : \infty \check{P} \infty = 112^\circ 15')$ .

(1) Comp Annual Report for 1847 and 1848, I, 470

(2) Wien Acad Ber June, 1850, 77, J Pt Chem LI, 432.

(3) Arch Pharm [2] LXIII, 1

Camphor  
of  
parsley.

**Camphor of Parsley.**—Loose(1) found in old *aqua petroselinæ* a deposit of long prisms, of the lustre of mother-of-pearl, and of a yellow powder. The yellow powder was uncrystalline, fusible, forming crystals when sublimed, soluble in hot alcohol, producing a solution of an acid reaction, from which water separated a yellow powder, and on cooling and spontaneous evaporation yellow crystals were deposited. The white crystals melted even by the heat of the hand, forming a liquid which congealed at  $6^{\circ}$ ; they were soluble in cold alcohol, ether, fatty and essential oils.—L. Bley(2) has made on this occasion, a recapitulation of the former observations on the camphor of parsley.

**Helenin.**—The stearoptene contained in the root of *Inula Helenium*, which Gerhardt(3) termed helenin, and which he extracted by means of strong alcohol, can readily be prepared, according to Delffs(4), in the following manner: the fresh root is cut in slices, boiled with alcohol of 80 per cent, and the liquor, filtered whilst hot, is mixed with 3 or 4 times its bulk of cold water, when the helenin is completely deposited after twenty-four hours, in the form of white, long needles. From the dried root helenin may also be extracted, but apparently in less quantity.

**Caryophyllin.**—J. S. Muspratt(5) found caryophyllin to possess the composition  $C_{10}H_8O$ , which formula has already been obtained by Dumas(6) and corroborated by Ettling(7) and Mylius(8). Muspratt extracted the caryophyllin from cloves by ether, separated it by means of water, and purified it by boiling with ammonia; caryophyllin sublimes at about  $285^{\circ}$ , according to Muspratt.

Stenhouse(9) has made communications on the oils which are formed by the action of sulphuric acid on various vegetable substances.

**Furfurol.**—*Furfurol*(10) is prepared most advantageously, according to him, by distilling bran with rather more than half its weight of sulphuric acid, previously diluted with 2 parts of water. In order to make larger quantities of furfurol, he recommends to use 32 lbs. of wheaten bran and 20 lbs. of sulphuric acid, diluted with twice its weight of water, and to effect the distillation by steam; the strongly acid distillate is neutralized with chalk (it is advisable not to neutralize completely to avoid decomposition by the excess of the base),

(1) Arch. Pharm. [2] LXIII, 267.

(2) Arch. Pharm. [2] LXIII, 271.

(3) Ann. Ch. Phys. [2] LXXII, 163; Berzelius' Jahresber. XX, 382; Ann. Ch. Phys. [3] XII, 188; Berzelius' Jahresber. XXV, 659.

(4) Pogg. Ann. LXXX, 440.

(5) Pharm. J. Trans. X, 343.

(6) Ann. Ch. Phys. [3] LIII, 166; Berzelius' Jahresber. XIV, 293.

(7) Liebig's Handb. d. Organ. Chemie, 338.

(8) J. Pr. Chem. XXII, 105; Berzelius' Jahresber. XXII, 452.

(9) Ann. Ch. Pharm. LXXIV, 278; a short notice of the results, Phil. Mag. [3] XXXVII, 226; Instit. 1850, 412.

(10) The former investigations on this subject referred to in the above, see Annual Report for 1847 and 1848, II, 50.

one half of the liquor is distilled off, the distillate repeatedly rectified, and the oil separated by saturating with chloride of sodium and again distilling; in this manner between 12 and 13 ounces of oil are obtained from the above quantity of bran. This crude furfurool contains always a considerable amount of acetone. Stenhouse obtained also furfurool from expressed linseed, from the woody shells of cocoa-nuts, and from mahogany wood; the oil prepared from the latter substance is especially free from resin, and can therefore be readily purified.—Crude furfurool always contains another aromatic oil admixed which possesses a higher boiling-point, is very oxydizable, and on distillation is chiefly converted into brown resin; it produces instantaneously a purple colour when mixed with a few drops of concentrated hydrochloric, nitric, or sulphuric acids; this reaction has formerly been erroneously stated by Stenhouse and Fownes to be characteristic of furfurool; pure furfurool, however, does not exhibit it. Stenhouse terms this oil *metafurfurool*. Furfurool can be freed from *metafurfurool* by repeated rectifications, when the latter remains behind, being the less volatile of the two and more readily oxydized. The absence of *metafurfurool* is recognized by boiling the aqueous solution of furfurool with excess of quicklime for a few minutes, and adding hydrochloric or sulphuric acids in excess to the dark yellow liquor; when *metafurfurool* is present a deep red colour ensues, but none when the furfurool is pure. Furfurool is converted into a blackish-brown resin by strong hydrochloric or sulphuric acids, without the formation of the red hue. *Metafurfurool* is less soluble in water and in aqueous ammonia; it does not form a crystalline amide with the latter, but is converted by it into a brown, resinous mass; nitric acid transforms it into oxypicric or a similar acid, whilst furfurool is thereby completely converted into oxalic acid.

*Bichloride of platinum and furfurine* was obtained by Stenhouse on adding bichloride of platinum to a hot solution of hydrochlorate of furfurine in weak alcohol; it crystallized, on cooling, in the form of long pale yellow needles which possessed the composition  $C_{30}H_{12}N_2O_6$ ,  $HCl + PtCl_2$ , previously found by Fownes for the double salt obtained as a pulverulent precipitate.—*Nitrate of furfurine*,  $C_{30}H_{12}N_2O_6$ ,  $HO$ ,  $NO_5$ , was obtained by Stenhouse from the alcoholic solution in regularly developed crystals; according to W. H. Miller(1), they form the rhombic combination  $P : \bar{P} \infty : \infty \bar{P} \infty, \infty \bar{P} 3, \infty \bar{P} \frac{3}{2}$  (angles of the terminal edges of  $P = 144^\circ 16'$  and  $135^\circ 18'$ ; angles of the lateral edges of  $P = 58^\circ 44'$ ;  $\bar{P} \infty : \bar{P} \infty$  in the brachydiagonal principal section  $= 141^\circ 20'$ ; cleavage parallel to  $\infty \bar{P} \infty$  very perfect).

**Fucusol.**—Stenhouse treated sea-weeds in a like manner to the bran in the preparation of furfurool, especially *Fucus nodosus*, *F. vesiculatus*, *F. serratus*, and others. The oil he obtained from these

**Fucusol.** plants he terms *fucusol*; it always contains a considerable amount of acetone, which can be removed by washing with water, distilling and separating the first portion of the distillate. From metafurfurol or a similar oil it was freed in the same manner as furfurol, mentioned above. The algæ yielded only one-fourth of the quantity of oil obtained by Stenhouse from bran.—Fucusol, dried over chloride of calcium, and then rectified, is colourless whilst fresh, but assumes a yellow and brown colour in a few days, particularly when exposed to the light, and when it contains metafurfurol. In the pure state, and in hermetically-sealed tubes, it may be preserved for a long time, without undergoing any change. Its spec. grav. at  $13^{\circ}5$  is 1.150 (that of furfurol 1.1636); its boiling-point is between  $171^{\circ}$  and  $172^{\circ}$  (that of furfurol at  $166^{\circ}$ , according to Fownes and Cahours,  $162^{\circ}5$ : Stenhouse considers this latter statement to be too low, in consequence of an admixture of acetone). It resembles furfurol, but requires a little more water and ammonia for its solution; it assumes a green colour with hydrochloric acid, a pale yellow one with nitric acid, and a greenish-brown with sulphuric acid; when it contains metafurfurol, it is coloured purple by all these acids. Its composition is the same as that of furfurol ( $C_{15}H_6O_6$ ).—On mixing fucusol with 8 or 9 parts of a strong solution of ammonia, a pale yellow crystalline mass is formed after a few hours, which is *fucusamide*,  $C_{15}H_6NO_3$  (isomeric with furfuramide). It can be obtained in long fan-like grouped needles, by crystallizing it from hot alcohol. In alcoholic solution it forms, with sulphuretted hydrogen, *thiofucusol*, corresponding to thiofurfurol (thiofurfol). Subjected to dry distillation, thiofucusol is decomposed like thiofurfurol, a crystalline body being formed, which has been termed *pyrofucusol*; it crystallizes in needles, and is probably  $C_{18}H_{18}O_4(1)$ .—When pure fucusamide is boiled for twenty or thirty minutes with moderately concentrated solution of soda or potassa, it fuses into a pale brown oil, solidifying on cooling; no ammonia is hereby disengaged. This oil contains a base, *fucusine*, and a brownish resin. The best method for obtaining pure fucusine from this is as follows: The mass is digested with nitric acid at a temperature a little above its melting-point; it is then cooled down in order to solidify the resin, the liquor is poured off, and the nitrate of fucusine allowed to crystallize. This is purified by repeated crystallizations, and when pure, its aqueous solution is decomposed by a slight excess of ammonia. Fucusine crystallizes slowly in small star-like grouped leaves. Its composition is, like that of furfurine,  $C_{30}H_{12}N_2O_6$ . At  $8^{\circ}$  it requires 2400 parts of water for its solution (half the quantity that furfurine requires); it is less soluble in aqueous alcohol than furfurine; its solution possesses an alkaline reaction.—*Nitrate of*

(1) Respecting the corresponding compound from thiofurfurol, comp. Annual Report for 1847 and 1848, II, 51.

*fucusine*,  $C_{30}H_{12}N_2O_6$ ,  $HO$ ,  $NO_5$ , the preparation of which has just been given, forms, according to W. H. Miller(1), rhombic crystals, with the faces  $\infty P . \infty \bar{P} \infty . P . \bar{P} \infty (\infty P : \infty P = 95^\circ 42', \bar{P} \infty : \bar{P} \infty$ , in the macrodiagonal principal section  $= 116^\circ 0'$ , angle of the terminal edges of  $P = 136^\circ 12'$  and  $119^\circ 18'$ , angle of the lateral edges of  $P = 71^\circ 0'$ ; cleavage parallel to  $\infty \bar{P} \infty$  perfect, less so parallel to  $\bar{P} \infty$  and  $P$ .—*Hydrochlorate of fucusine* is very soluble; it crystallizes in short flexible needles. The double salt, with bichloride of platinum, is separated, in the form of a yellow crystalline precipitate, on adding bichloride of platinum to a cold aqueous solution of hydrochlorate of fucusine. When both solutions are mixed warm, and a little alcohol is added, it crystallizes on cooling in broad four-sided prisms. Its composition is  $C_{30}H_{12}N_2O_6, HCl + PtCl_2$ .—The bin-oxalate of fucusine can easily be prepared by digesting crude fucusine with an excess of oxalic acid; the solution, filtered whilst hot, deposits, on cooling, small needle-shaped crystals which are decolorized by animal charcoal and recrystallized. Their composition is  $C_{30}H_{12}N_2O_6, HO, C_2O_3 + HO, C_2O_3$ . The neutral salt is more soluble.

Fucusol.

Moss (*Sphagnum*), treated like bran and sea-weeds in the preparation of furfurol and fucusol, yielded a considerable quantity of an oil, apparently identical with fucusol; lichens (*Cetraria islandica*, *Usnea*, and others) produced the same. Ferns (*Pteris aquilina*) yielded an oil which appeared to differ from fucusol as well as from furfurol.

**Balsams.**—Scharling(2) has communicated more fully his experiments on the action of potassa on balsams, which have already been quoted in last year's Report(3).

**White Balsam of Sonsonate. Myroxocarpin.**—The white balsam of Sonsonate(4) is, according to Stenhouse(5), pretty freely dissolved when digested with ordinary spirits of wine. The clear solution deposits, after standing for twelve hours, large white crystals, which are obtained in a state of purity when recrystallized with a little animal charcoal. Stenhouse assigns to it the name of *myroxocarpin* (because the balsam is probably obtained from the fruits of *myrospermum*). These crystals belong, according to W. H. Miller, to the rhombic system,  $\infty P . 0 P . \infty \bar{P} \infty . \bar{P} \infty . 2 \bar{P} \infty . \bar{P} \infty . 2 \bar{P} \infty (\infty P : \infty P = 102^\circ 12'; \bar{P} \infty : 0 P = 127^\circ 4'; 2 \bar{P} \infty : 0 P = 110^\circ 41'$ ;

(1) Ann. Ch. Pharm. LXXIV, 293.

(2) From Oversigt over det Danske Vidensk. Selskabs Forh. 1849, 9 in Ann. Ch. Pharm. LXXIV, 230; J. Pr. Chem. L, 442.

(3) Annual Report for 1849, III, 310.

(4) On the origin and the properties of this balsam, see Pereira, Pharm. J. Trans. X, 280; Ann. Ch. Pharm. LXXVII, 309.

(5) Pharm. J. Trans. X, 290; Ann. Ch. Pharm. LXXVII, 306.

White bal-  
sam of  
Sonsonate.  
Myroxo-  
carpin.

$\tilde{P} \infty : O P = 133^{\circ} 7'$ ;  $2 \tilde{P} \infty : O P = 115^{\circ} 5'$ ; ratio of the principal axis to the secondary axes  $= 1 : 0.9363 : 0.7553$ ). Stenhouse found for myroxocarpin the composition  $C_{48}H_{35}O_6$ . It is insoluble in water, soluble in alcohol and ether, forming neutral solutions: it is tasteless, does not decrease in weight at  $100^{\circ}$ , melts at  $115^{\circ}$  to a transparent glass which does not again crystallize on cooling: exposed to a higher temperature, a small portion of it sublimes, and the remainder is converted into an 'uncrystallizable resin, whilst at the same time a considerable quantity of acetic acid is formed. Myroxocarpin is chemically very indifferent; it is not changed by boiling with potassa, and is only with difficulty attacked by acids. When heated with strong nitric acid, it is slowly decomposed into oxalic acid and an uncrystallizable resin (no picric acid is hereby formed): by chlorine and bromine it is, but very slowly, converted into an uncrystallizable resin.

**Storax. Styracin.**—In last year's Report (p. 311, sqq.), we have mentioned some investigations on liquid storax, and on the styracin contained in it, as well as on the products of decomposition of the latter: we have stated (page 313) that Strecker has proposed the formula  $C_{36}H_{16}O_4$  for styracin, and the formula  $C_{18}H_{10}O_2$  for Toel's (1) styrone. According to these formulæ, styrone would bear the same relation to cinnamic acid,  $C_{18}H_8O_4$ , as alcohol does to acetic acid, and styracin could be considered as consisting of styrone and cinnamic acid, *minus* 2<sup>e</sup> equivs. of water.—Strecker has now proved (2) that styracin possesses indeed the composition  $C_{36}H_{16}O_4$ , when completely purified by repeated crystallizations from alcohol and ether.

The same result has been arrived at by J. Wolff (3). He prepared styracin by a process essentially that given by Toel, viz.: by distilling liquid storax with carbonate of soda when styrol passes over and styracin remains behind, mixed with cinnamate of soda and resin; the crude styracin being washed, becomes crystalline in from one to three days, when cold alcohol is poured upon it; it can readily be separated from the resin by dissolving it in alcohol and adding acetate of lead. It is purified by recrystallization from alcohol and ether, and by pressure between bibulous paper; it cannot very well be purified by means of animal charcoal. When not quite pure, it assumes a brown colour on being exposed to the air. The composition of the pure styracin, dried *in vacuo*, corresponds to the formula  $C_{36}H_{16}O_4$ .—For the purpose of preparing styrone, styracin is distilled with a solution of caustic potassa of a spec. grav.  $= 1.20$ , when cinnamate of potassa is separated; or styracin is dissolved in boiling alcoholic solution of potassa, when, on cooling, cinnamate of potassa crystallizes and, on

(1) Annual Report for 1849, III, 312.

(2) Ann. Ch. Pharm. LXXIV, 112.

(3) Ann. Ch. Pharm. LXXV, 297; Chem. Gaz. 1850, 449; J. Pharm. [3] XXI, 153.

the addition of water, styrene and some undecomposed styracin are separated, which are separated by distillation. The styrene is extracted from the turbid distillate by means of ether, freed from ether by evaporation, and then rectified over chloride of calcium; after some time the styrene congeals to a crystalline mass, which melts by the heat of the hand, and boils at  $250^{\circ}$ , whilst in the liquid modification it remains fluid even at  $-10^{\circ}$ . Wolff found styrene to possess the composition  $C_{18}H_{10}O_2$ , as has been stated by Strecker. That it is really the alcohol of cinnamic acid ( $C_{18}H_8O_4$ ) is proved by its conversion into the latter. This transformation does not succeed by boiling with concentrated solution of potassa. On heating a mixture of binocide of lead, concentrated solution of potassa and styrene, the mass becomes first solid, it then melts whilst the binocide is reduced to protoxide or metal, and yields, as distillate, oil of bitter almonds (by a farther decomposition of cinnamic acid); in the alkaline residue much cinnamic acid is present, which crystallizes after separating the lead, heating to boiling and neutralizing with acetic acid; its identity was established by analyzing the pure acid as well as the silver-salt. On heating styrene with a large quantity of nitric acid, oil of bitter almonds passes over, and the residue contains benzoic acid; if the formation of nitrous vapours be prevented by an addition of urea, less oil of bitter almonds distils, and the residue contains nitro-cinnamic acid. By the oxydation of styrene with bichromate of potassa and sulphuric acid, or with chromic acid, cinnamic acid is likewise formed. Wolff farther adds, that styrene is rendered dark purple by fuming sulphuric acid, and solidifies into a sticky mass, which forms a soluble baryta-salt when neutralized with carbonate of baryta.

**Resin of Juniper Berries.**—Du Mênil(1) has communicated some remarks on the extract and resin of juniper berries.

**Resin of Jalappa.**—Sandrock(2) has investigated the resin of the root of *Ipomoea Schiedeana*, and has arrived at results different from those of Kayser(3). Alcohol of 80 per cent extracted from the root about 15 per cent of resin; the alcoholic solution of the resin was purified with animal charcoal and precipitated with water. The resin thus purified was yellowish-white, easily soluble in alcohol, and partially so in ether; with concentrated sulphuric acid it formed a solution which, only after some time, assumed a purple colour and afterwards became brown, whilst dark flakes were deposited; by boiling with concentrated nitric acid it was converted into oxalic and another acid, considered by Sandrock to be styphnic acid; it was but little soluble in hydrochloric acid; the undissolved portion changed into a tough, brown resin; it readily dissolved in acetic

(1) Arch. Pharm. [2] LXII, 29.

(2) Arch. Pharm. [2] LXIV, 160.

(3) Ann. Ch. Pharm. LI, 81; Berzelius' Jahresber. XXV, 663.



Resin of  
Jalappa.

acid, and also in caustic potassa, ammonia and the alkaline carbonates when heat was applied. The resin consists, according to Sandrock, of three different kinds of resin, the one of which, *gamma-resin*, is soluble in ether, whilst *alpha-resin* is precipitated, by means of an alcoholic solution of acetate of lead, from the alcoholic solution of the resin, previously extracted by ether, and *beta-resin* remains in solution. The mixture of the two latter is the body which Kayser termed *rhodeoretin*; the *beta-resin* corresponds to the *jalappin* of Buchner and Herberger(1). By continued boiling of the mixture of *alpha*- and *beta*-resin with carbonate of soda, until, on addition of water or acid, no farther separation of resin appears, two acids are formed; this liquor evaporated, the residue extracted with alcohol, the alcoholic solution evaporated, mixed with water and precipitated with basic acetate of lead in excess, yields a precipitate of the lead-salt of the acid formed from the *alpha-resin*, viz.: *ipomic acid*, whilst the acid formed from the *beta-resin*, *jalappic acid*, remains in solution. The *ipomic acid* is identical with the *hydrorhodeoretin* of Kayser. We have to refer to the original concerning the particulars of Sandrock's statements (not supported by analyses) on the three resins, on the two acids just named, and also on the acid formed from the *gamma-resin* by the action of potassa.

**Resin of Guaiacum.**—Van den Broek(2) has continued(3) his experiments on the colouring of various parts of plants by tincture of guaiacum, and has extended them to a great number of plants. He considers it probable that the albuminous constituent of the plants causes this reaction: he says that, besides albumen, the plants contain other substances not sufficiently distinguished as yet, which also produce a colouring.

**Caoutchouc. Gutta Percha.**—Adriani(4) has published investigations on caoutchouc (of *Ficus elastica*), gutta percha (of *Isanandra Gutta*), and on several other substances connected with them.—The newly separated sap of *Ficus elastica* (by the inspissation of which caoutchouc is obtained), he found to contain the more water the nearer the part of the plant from which it flowed out was to the upper end. The sap from a terminal bud cut through, of a plant  $2\frac{1}{4}$  metres high, contained but 17·70 per cent of solid matter; the sap that flowed out immediately below it, 20·98 per cent; and that from the stem of a leaf, 30 centimetres above the ground, 25·15 per cent. The fresh sap has an acid reaction, and consists, when viewed under the microscope, of a clear limpid liquid, with a large quantity of caoutchouc globules floating in it. The sap from terminal buds contained 82·30 per cent of water, 9·57 of caoutchouc,

(1) Repert. Pharm. XXXVII, 103.

(2) Scheik. Onderzoek. V, 6. Stuk, 226.

(3) His former investigation, see Annual Report for 1849, III, 314.

(4) Verhandelng over de Gutta Percha en Caoutchouc, Utrecht, 1850.

1.58 of resin, soluble in alcohol, but not in ether; 0.36 of the magnesia-salt of an organic acid (forming, with potassa and soda, salts which are but little soluble), and of a substance soluble in water and alcohol, but not in ether (sugar?), 2.18 of a substance soluble in water, rendered yellow by the alkalis (being neither vegetable albumin nor any other of the so-called protein-compounds), dextrin(?), and traces of lime- and soda-salts.—The spec. grav. of caoutchouc was found by Adriani (after carefully removing adhering bubbles of air) = 0.9628 at 20°, of caoutchouc in bottles = 0.9454, that of crude gutta-percha = 0.999, that of rolled gutta-percha, 0.966. Boiling water extracted but little from gutta-percha; in one instance, 0.042 per cent: the water assumed an acid reaction which disappeared on evaporation: no appreciable quantity was extracted from caoutchouc. Cold alcohol extracted from gutta-percha a resin (varying in quantity in the different sorts), and boiling alcohol after that a white, wax-like fat (also in variable quantities). From caoutchouc cold alcohol extracted scarcely anything; boiling alcohol, however, 4.8 per cent of a pale-yellow, glutinous resin. Ether extracted from one sort of gutta-percha, previously treated with water and alcohol, 13.6 of a resin; from another sort, nothing at all. 1 part of gutta-percha which had been treated with water, alcohol and ether, required from 4 to 6 parts of oil of turpentin in order to produce a solution capable of being filtered: from this solution the gutta-percha is precipitated by alcohol; the precipitate, after being exhausted with alcohol, is white, but assumes gradually a yellow tint on keeping. The best method for preparing the principal constituent of gutta-percha is treating with water, alcohol and ether, dissolving in chloroform, filtering, precipitating and washing with alcohol, drying between 70° and 80°, when it is obtained perfectly white. In bisulphide of carbon, gutta-percha is also soluble, as is already known. The substance of caoutchouc may also be prepared in a state of purity by dissolving in chloroform, and precipitating with alcohol: it then resembles gum-arabic. Purified gutta-percha and purified caoutchouc do not contain any nitrogen.—When subjected to dry distillation, gutta-percha yields at 100° a yellow oil of a penetrating, but not disagreeable odour; at a higher temperature, dark-coloured, oily substances. 50 grms. of gutta-percha, distilled on a sand-bath until no farther product passed over, gave 28.83 grms. of a volatile oil, of 0.909 spec. grav.; 50 grms. of caoutchouc produced, by the same process, 42.884 grms. of oil, with which, however, a little water was mixed. In crude gutta-percha, Adriani found 5.18 per cent of ashes; in the pure substance, prepared with chloroform, 0.314; in crude caoutchouc 0.487; in that purified by chloroform, 0.333: the ashes contained carbonic acid, lime, sesquioxide of iron, traces of potassa, magnesia, and silica. In

Caout-  
chouc.  
Gutta-  
percha.

vulcanized or sulphuretted caoutchouc(1), Adriani found from 8 to 11 per cent of sulphur. Caoutchouc, thus prepared, is no longer soluble in chloroform.—The sap of a tree, coming from Palembang, inferior to gutta-percha, and used for its adulteration, to which the name *Getah malabeöya* has been assigned, fuses at 170°, and produces, when treated with boiling water, a milky neutral liquor which is precipitated by alcohol; otherwise, this substance exhibits a chemical deportment similar to that of gutta-percha, and especially is soluble in chloroform.

**Colouring Matters. Madder.**—Our knowledge on the red colouring substances in madder has been enlarged(2) by the investigations of Wolff and Strecker(3). Madder contains, according to these chemists, in addition to yellow and orange colouring matters, two red pigments, *alizarin* and *purpurin*. Alizarin was first obtained by Robiquet and Colin, and designated by this name: it is identical with Runge's *Krapproth*, and with the *matière colorante rouge* of Persoz and Gaulthier de Claubry (which, however, was not obtained in a perfectly pure state). It was prepared in a state of purity by Schunck and Debus, and termed *lizaric acid* by the latter. The other pigment, which has first been distinguished by Robiquet and Colin as *purpurin* (however, not prepared in a state of purity) is identical with Runge's *Krapp-purpur* and Debus' *oxylizaric acid*. Higgin prepared it mixed with alizarin, and assigned to it the latter name; Schunck overlooked it.

In order to prepare alizarin, Wolff and Strecker tried the various methods of Runge, Debus, and Schunck, and fixed at last upon the following which comes nearest to that of Schunck. Ordinary madder of Avignon is exhausted with boiling water, and the decoction precipitated by means of sulphuric acid. The washed precipitate is boiled, whilst yet moist, with a concentrated solution of hydrated alumina in hydrochloric acid, when the pigments are dissolved, and dark-coloured substances are left behind. On adding a small quantity of hydrochloric acid to the solution, fire-red, sometimes crystalline flakes are separated. These contain, besides alizarin, also purpurin, and perhaps brown resinous substances, if these latter be not formed by the subsequent process. The precipitate is dis-

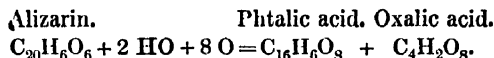
(1) Annual Report for 1847 and 1848, II, 59.

(2) Respecting former investigations on this subject, see Annual Report for 1847 and 1848, II, 77, especially on those of Schunck, page 77, (also Annual Report for 1849, III, 314); of Higgin, page 85; and of Debus, page 87.

(3) Ann. Ch. Pharm. LXXV, 1; Chem. Soc. Qu. J. III, 243; preliminary notice of the results, Compt. Rend. XXXI, 206; Laur. and Gerh. C. R. 1850, 313; J. Pharm. [3] XVIII, 238.

solved in alcohol or in dilute ammonia, and freshly precipitated alumina is added which combines with the colouring matters. On boiling the alumina-compound with a concentrated solution of carbonate of soda, purpurin is dissolved, with a deep-red colour, whilst alizarin remains in combination with the alumina. This boiling is repeated so long as the solution of soda becomes highly coloured: the alizarin-alumina is then freed from an admixture of resins by treating it with ether, and decomposed by hot hydrochloric acid: the alizarin thus separated is filtered off, and washed. The alizarin dried in the air is purified by repeated crystallizations from alcohol. It is obtained in two different forms, occasioned by a difference in the amount of water. The hydrated alizarin forms scales resembling mosaic gold; the anhydrous possesses a red colour which changes more or less into yellow, according to the thickness of the crystals. When heated, alizarin melts and sublimes in orange-coloured needles (being thereby partially decomposed, and leaving some charcoal behind). It is with difficulty wetted by cold water; in boiling water, it dissolves with a deep-yellow colour: the least trace of alkali imparts a red colour to the solution. This is also the case with the solution in alcohol which dissolves alizarin readily with a yellow colour, but not with the solution in ether. Alizarin is very soluble in the alkalies; the solution in hydrate of potassa or soda, when somewhat concentrated, is deep-purple in transmitted light; and of a pure blue, in reflected light: when very dilute, it is uniformly violet. By ammonia or the alkaline carbonates, however, alizarin is dissolved with a colour resembling that of orcein; but the solution does not exhibit the blue colour on the surface. The cause of the difference in colour of the solutions of alizarin, in the caustic alkalies and their carbonates, is the formation of various compounds of alizarin and alkali, one of which was isolated in the following manner: Alizarin was dissolved in a cold saturated solution of carbonate of soda, heat being applied: the compound of alizarin and soda, separating on cooling the filtered solution, was dried, freed from an admixture of carbonate of soda by dissolving it in absolute alcohol, and then precipitated from this solution by means of ether in the form of purple flakes. This compound dissolves with facility in water and in alcohol, forming a solution of the colour of orseille, which is rendered blue on addition of caustic soda. The compounds of alizarin with the alkalies are insoluble in cold and concentrated solutions of salts. The ammoniacal solution of alizarin produces, with chloride of barium, an almost purely blue flocculent precipitate (the solution, filtered off is colourless), and, with acetate of lead, a purple one. Alizarin does not dissolve in a cold, and but little in a boiling solution of alum: it dissolves with a red colour in hydrated sulphuric acid, and is again separated from it on the addition of water.—Wolff and Strecker assign to alizarin, when dried between  $100^{\circ}$  and  $120^{\circ}$ , the formula  $C_{20}H_6O_6$ ,

**Madder.** according to the analyses of Schunck and Debus, with which the amount of carbon, found by themselves, agrees. The hydrated alizarin contains, in addition, 4 equivs. of water, according to Schunck's experiments. The compounds obtained by Schunck, on precipitating the ammoniacal solution with chloride of calcium or barium, are expressed, when dried at  $100^{\circ}$ , by the formulæ:  $2 (C_{20}H_6O_6) + 3 (CaO, HO)$ , and  $2 (C_{20}H_6O_6) + 3 (BaO, HO)$ : the compound, with protoxide of lead, obtained by Schunck, by the formula  $2 (C_{20}H_6O_6) + 3 PbO$ ; the compound of lead obtained by Debus, and dried at  $120^{\circ}$ , by the formula  $3 (C_{20}H_6O_6) + 4 PbO$ . Neutral compounds of alizarin and baryta could not be prepared. By treating with an excess of baryta a solution of alizarin in dilute alcohol, and freeing the precipitate from the excess of baryta by washing it with water, the air being excluded, and from an admixture of alizarin by treating it with warm alcohol, and then drying at  $100^{\circ}$ , a compound,  $C_{20}H_6O_6 + 2 (BaO, HO)$ , was obtained in one instance; and in another, a compound,  $2 (C_{20}H_6O_6) + 3 BaO, HO$ : the latter lost 3 equivs. of water at  $120^{\circ}$ . By dissolving alizarin in ammonia, removing the excess of ammonia by gentle evaporation, precipitating the solution with chloride of barium, and drying it at  $120^{\circ}$ , a compound,  $3 (C_{20}H_6O_6) + 2 BaO$ , was obtained.—The identity with phthalic acid(1) of the acid formed from alizarin by oxydizing agents, and termed by Schunck alizaric acid, has been verified by the analysis of the silver-salt. Wolff and Strecker give the following explanation for the formation of this acid:



The new formula for alizarin,  $C_{20}H_6O_6$ , brings this substance in close relationship with Laurent's *chloronaphthalic acid*(2),  $C_{20}H_5ClO_6$ , which would be, accordingly, chlorinnetted alizarin: in fact, there are resemblances between both substances such as are exhibited by products of substitution so near to each other, and the chloronaphthalic acid also forms, with nitric acid, according to Laurent, oxalic and phthalic acids ( $C_{20}H_5ClO_6 + 4 HO + 6 O = C_{16}H_6O_8 + C_4H_2O_8 + HCl$ ). Wolff and Strecker attempted, however, in vain, by the action of an amalgam of potassium, and by the electric current, to replace the 1 equiv. of Cl in chloronaphthalic acid(3) by 1 equiv. of H, and thus to produce alizarin artificially from chloronaphthalic acid.

(1) Annual Report for 1847 and 1848, II, 82.

(2) Ann. Ch. Phys. [2] LXXIV, 26; Berzelius' Jahresber. XXI, 506.

(3) Whilst preparing chloronaphthalic acid, Wolff and Strecker obtained once *dichloronaphthalic acid*, as yet not described (in addition to another acid, most likely di- or tri-chlorinnetted naphthalic acid); by saturating the boiling alcoholic solution with solution of potassa, the potassa-salt was deposited shortly after, in the form of tables of a silvery lustre; it is, when dried at  $140^{\circ}$ ,  $C_{16}H_2Cl_2K_2O_8$ .

The separation of alizarin from purpurin is given, p. 355; purpurin thus dissolved can, however, only with great difficulty, be obtained in a pure state. The following method has been proved to answer better for the purpose of preparing purpurin. Madder of Alsace and of Avignon was fermented with yeast and water in a warm place, the air being excluded; after the fermentation had ceased, the liquor exhibited an acid reaction, and yielded by distillation a considerable amount of alcohol as well as a small quantity of a volatile acid. Boiling water extracted but a very small quantity from the fermented madder previously washed with water; when boiled with a concentrated solution of alum, the liquor became deep red, in reflected light orange-coloured. On cooling the solution containing alumina, and adding sulphuric acid, red flakes separated which consisted of purpurin, free from every trace of alizarin; they were freed from a small quantity of alumina by boiling with hydrochloric acid and then recrystallizing from alcohol and from ether. Purpurin crystallizes from a solution in strong alcohol in the form of red needles, from weak alcohol in fine, tender, orange-coloured needles, the latter containing water of crystallization which they give off at  $100^{\circ}$ , whilst they assume a red colour. Purpurin is more soluble in water than alizarin, forming a red solution; it is pretty soluble in a boiling solution of alumina with a pale red colour, a great portion of it remains dissolved on cooling. Its alcoholic solution has also a deeper red colour than that of alizarin. It is soluble in ether and in concentrated sulphuric acid; in solution of potassa it dissolves with the colour of cherries without the blue appearance characteristic of alizarin. Purpurin dissolved in ammonia produces purple precipitates with lime-, baryta- and lead-salts. Purpurin is insoluble in a concentrated solution of carbonate of soda when cold, but soluble on boiling; its compounds with the alkalis are insoluble in solutions of salts. When heated, it melts and sublimes, leaving in most cases charcoal behind.—According to experiments made by Wolff and Strecker, cloth mordanted with alumina assumes a deep red colour with purpurin, whilst it possesses a bluish tint when dyed with alizarin; purpurin acts, according to these chemists, a very important part in the ordinary dyeing, as well as in Turkey-red dyeing, and it is, for the latter purpose at least, preferable to alizarin.—They assign to the anhydrous purpurin the formula  $C_{18}H_6O_6$ , agreeing with the analyses of Debus, and to the hydrated purpurin the formula  $C_{18}H_6O_6 + HO$ , according to their own determination of the amount of water; the lead-compound prepared by Debus they consider to be a mixture, the composition of which is, however, exactly represented by the formula  $5 C_{18}H_6O_6 + 6 PbO$ .—The fermented madder yielded only purpurin, and Strecker and Wolff assume that the alizarin is by this means converted into purpurin, whilst carbonic acid and water are at the same time given off.—By nitric acid purpurin is

Fustic.

attacked with greater difficulty than alizarin; it likewise produces, when boiled with nitric acid, phthalic and oxalic acids ( $C_{18}H_6O_6 + HO + 5 O = C_{16}H_6O_8 + C_2HO_4$ ).

**Fustic.**—R. Wagner(1) has examined the colouring matters in fustic (the wood of *Morus tinctoria* Jacq., *Broussonetia tinctoria* Kunth), which were formerly investigated, especially by Chevreul(2). The latter found in fustic two pigments which are yellow dyes for stuffs mordanted with alum; he called them white and yellow morin.—Wagner boiled fustic repeatedly with water, filtered the boiling decoction, concentrated the liquor by evaporation, and left it for several days to itself; after the lapse of a few days, a yellow sediment was formed consisting chiefly of morin-lime; the supernatant, brown liquor contained a peculiar tannic acid, also acting as a dye, *morin-tannic acid*.

The yellow sediment was pressed out, dissolved in boiling alcohol, and the alcoholic solution poured into 8 or 10 times its bulk of water; morin-lime is thus separated, and is purified by repeating this operation several times, when morin-tannic acid remains in solution. Thus prepared, it forms a sulphur-coloured, crystalline powder, and, when separated from its alcoholic solution, small, sulphur-coloured crystals.—In order to separate *morin*, the preceding compound is boiled with alcohol and a quantity of oxalic acid, corresponding to the quantity of lime (amounting to about 6.8 per cent), the solution is filtered whilst hot, and poured into a considerable quantity of water; morin is separated as a crystalline, yellowish-white powder; it is purified by repeatedly dissolving it in alcohol and precipitating with water; it is then dried at  $100^\circ$ , the air being excluded as much as possible. Thus prepared, it is a white, crystalline powder, which assumes in the air quickly a pale yellow cast; it is soluble in 4000 parts of water at  $20^\circ$ , and in 1060 parts of water at  $100^\circ$ , and forms with alcohol and ether dark yellow solutions of a feebly acid reaction, which are not precipitated by gelatin. The assumption of a yellow colour by morin and its aqueous solution when exposed to the air (not in the light), is caused by an absorption of ammonia, and not by oxydation. It is soluble in concentrated sulphuric acid with a yellow colour, apparently without decomposition; nitric acid converts it into styphnic acid; with other dilute acids it forms colourless, with alkalis, yellow solutions. Sesquichloride of iron produces with morin a garnet-red colour, sulphate of protoxide of iron an olive-green precipitate; salts of protoxide of copper, when boiled with morin and potassa, are reduced, suboxide of copper being separated; nitrate of silver is instantaneously reduced, especially on adding a little ammonia.

(1) J. Pr. Chem. LI, 82; Ann. Ch. Pharm. LXXVI, 347; Chem. Gaz. 1851, 21; J. Pharm. [3] XIX, 149.

(2) La Chimie appliquée à la Teinture, II, 150.

Morin does not decrease in weight at  $120^{\circ}$ ; it begins to give off its water at  $180^{\circ}$ ; and is still nearly unchanged at  $250^{\circ}$ . It blackens at  $300^{\circ}$ , when carbonic acid is given off and an oil distils which forms crystalline grains on cooling; in addition to these, phenol is formed. Wagner assumes for morin the formula  $C_{18}H_8O_{10}$ , for the crystalline morin-lime  $CaO$ ,  $C_{18}H_7O_9 + HO$ ,  $C_{18}H_7O_9$  (2 H $O$  are separated at  $100^{\circ}$ ), for morin-baryta (obtained in the form of a reddish-brown powder by boiling morin with freshly-precipitated carbonate of baryta and evaporating the solution), dried at  $100^{\circ}$ ,  $3 (BaO, C_{18}H_7O_9) + HO$ ,  $C_{18}H_7O_9$ . No compounds of a constant composition could be obtained with protoxide of lead and with the alkalis.

The deposits in the middle of logs of fustic consist chiefly of morin-tannic acid, and this acid can easily be prepared from them by dissolving them in boiling water, repeatedly recrystallizing the substance which is separated on cooling, dissolving it in a rather larger quantity of water acidulated with hydrochloric acid, and filtering the solution as often as it becomes turbid; when the solution remains clear, morin-tannic acid separates, on standing for some time, as a pale yellow, crystalline powder. It has a sweet, astringent taste, dissolves in 6.4 parts of water at  $20^{\circ}$ , in 2.14 at  $100^{\circ}$ , is very soluble in alcohol, wood-spirit and ether; the ethereal solution is yellowish-brown in transmitted light and, in reflected, greenish. It dissolves in cold concentrated sulphuric acid with a pale colour without undergoing any change; when heated, the solution becomes brown, sulphurous acid and the odour of phenol being emitted; from the solution prepared in the cold, a brick-coloured crystalline body separates after a few days, which assumes a purple colour by the slightest trace of ammonia. The same substance is formed by boiling morin-tannic acid with dilute hydrochloric acid; when boiled with concentrated hydrochloric acid, it is converted into a humus-like substance. Dilute nitric acid transforms it into a brown resin, oxalic acid being formed at the same time. It is completely precipitated by solution of isinglass and by softened animal bladder. With sulphate of proto-sesquioxide of iron it produces a greenish-black precipitate; by tartrate of oxide of antimony and potassa (tartar emetic) it is partially precipitated; with neutral acetate of lead it forms a yellow precipitate, soluble in boiling water, and again separating on cooling, in distinct lemon-coloured crystals; it forms dark yellow solutions with the caustic alkalies and their carbonates, which soon become brownish-black in the air; its aqueous solution is not precipitated by acids. The composition of the acid, dried at  $100^{\circ}$ , is, according to Wagner, probably  $C_{18}H_8O_{10}$  (the same as that of morin); that of the crystalline lead-precipitate  $C_{18}H_5O_7 \left( \begin{smallmatrix} 2 PbO \\ HO \end{smallmatrix} \right) + 2 C_{18}H_5O_7 \left( \begin{smallmatrix} PbO \\ 2 HO \end{smallmatrix} \right) + HO$ ; that of another lead-compound  $C_{18}H_5O_7, 2 PbO, HO$ ; the latter was



**Fusile.** prepared by precipitating a boiling solution of the acid with basic acetate of lead, and formed a chrome-yellow, uncrystalline powder, almost insoluble in water. The composition of morin-tannate of lime is  $2 \text{C}_{18}\text{H}_5\text{O}_7 + \text{CaO}, \text{HO} + 2 \text{HO}$ ; it was obtained by boiling morin-tannic acid with carbonate of lime, filtering the hot liquor, dissolving the yellowish-brown flakes which separated in boiling alcohol, and precipitating with water, when microscopic, yellow crystals were deposited; morin-tannate of sesquioxide of iron  $= \text{Fe}_2\text{O}_3 + 3 \text{C}_{18}\text{H}_5\text{O}_7$ ; morin-tannate of quinine  $= \text{C}_{38}\text{H}_{22}\text{N}_2\text{O}_4 + 2 \text{C}_{18}\text{H}_5\text{O}_7, 3 \text{HO}$ ; the latter was prepared by precipitating morin-tannate of lime with hydrochlorate of quinine, and forms a yellow uncrystalline precipitate. These compounds were all dried at  $100^\circ$ ; in the salts only the amount of the metallic oxide was determined in most cases.—The acid, when dried at  $100^\circ$ , melts at  $200^\circ$ , gives off water of an acid reaction at  $250^\circ$ , and is decomposed above  $270^\circ$ , carbonic acid being given off; a substance passed over at the same time, which Wagner took for phenol, and, in addition to this, a crystalline acid, termed pyromorin-tannic acid.

**Colouring Matters in Sandal-wood.**—Weyermann and Häffely(1) attempted to prepare the colouring matters contained in sandal-wood, according to the statements of L. Meier(2), and to determine their composition. The *santalic acid*, prepared according to Meier's prescription, exhibited, generally speaking, the properties described by him; it was not soluble in water, but dissolved readily in alcohol with a blood-red colour, and likewise in the alkalis with a dark violet colour; it also dissolved in warm acetic acid and in concentrated sulphuric acid. It was obtained free from inorganic constituents by adding to the alcoholic solution some hydrochloric acid and precipitating with water; on being again dissolved in alcohol and the solution evaporated, the acid was obtained as a crystalline powder, which, when dried at  $100^\circ$ , was  $\text{C}_{30}\text{H}_{13}\text{O}_{10}$ . By precipitating the solution in aqueous ammonia with chloride of barium, a dark violet salt was obtained, which, when washed with water, the air being excluded as much as possible and then dried at  $100^\circ$ , had the composition  $\text{BaO}, \text{C}_{30}\text{H}_{13}\text{O}_9$ . The alcoholic solution of santalic acid produced with an alcoholic solution of neutral acetate of lead a precipitate, the composition of which, after it was washed with alcohol and dried at  $100^\circ$ , was expressed by the formula  $\text{PbO}, \text{C}_{30}\text{H}_{13}\text{O}_9 + \text{PbO}, \text{HO}$ .—Meier's *santaloxide* could be obtained neither by the method prescribed by himself, nor by any other. The substances termed by Meier *santalide*, *santalöide*, *santalidide* and *santalöidide*, which he stated are contained in the aqueous extract of sandal-wood, also could not be obtained, the aqueous extract of several pounds of the wood leaving,

(1) Ann. Ch. Pharm. LXXIV, 226; Chem. Gaz. 1850, 353.

(2) Annual Report for 1847 and 1848, II, 90.

on evaporation, only a small quantity of a gummy substance, containing but little colouring matter.

Colouring-matter in rhubarb.

**Colouring Matter in Rhubarb.**—Garot(1) gives the name of *erythro*se to the yellow or orange-coloured substance which remains behind on treating rhubarb with 4 times its quantity of nitric acid; he acknowledges, however, that this is a mixture of different bodies. French rhubarb yielded from 8 to 10, exotic rhubarb from 15 to 20 per cent of this residue. Alcohol and ether extract from erythro~~se~~ a substance said to be identical with Geiger's rhubarbin and Brande's rhubarbic acid; erythro~~se~~ yields with the alkalis red solutions (*erythro*sates, according to Garot), which stain very intensely, but in different degrees according to the origin of the rhubarb.—Meurein(2) found that erythro~~se~~ is chiefly formed by that portion of the rhubarb which is soluble in water and in alcohol; root, previously treated with these solvents, yields but little.—In the investigation of Garot and of Meurein, the recent investigations of the constituents of the rhubarb have not been taken into account(3).

On the yellow colouring matter contained in *Equisetum fluviatile*, comp. p. 254.

**Sugar. Decomposition by Lime.**—The products formed by the distillation of sugar with lime have previously been examined by Fremy(4) and Gottlieb(5); of late this subject has again been investigated by R. Schwarz(6); the results arrived at by him are essentially the following. On distilling sugar with from 3 to 8 times its amount of lime, inflammable gases are given off and a fluid distillate passes over. If the latter be mixed with water and again distilled, a small quantity of resinous substance remains behind; the distillate is partially soluble in water. The portion insoluble in water imparts a brown colour to a cold aqueous solution of potassa when brought in contact with it, and after being repeatedly treated with a solution of potassa and washed with water, a mobile liquid of an ether-like odour is obtained which, when the air has acted upon it, has again the property of imparting a dark colour to a solution of potassa; this is a mixture of several compounds, the separation of which has been attempted by fractional distillation; in this manner, liquids were

(1) J. Pharm. [3] XVII, 5.

(2) J. Pharm. [3] XVII, 179.

(3) Schlossberger and Döpping (Ann. Ch. Pharm. L, 196; Berzelius' Jahresber. XXV, 678) found in the root of the rhubarb chrysophanic acid, the transformation of which by nitric acid has been investigated by Rochleder and Heldt (Ann. Ch. Pharm. XLVIII, 1; Berzelius' Jahresber. XXIV, 387).

(4) Ann. Ch. Phys. [2] LXIX, 5; Berzelius' Jahresber. XVI, 332.

(5) Ann. Ch. Pharm. LII, 127; Berzelius' Jahresber. XXV, 554.

(6) Wien. Acad. Ber. July, 1850, 159; J. Pr. Chem. LI, 374; Ann. Ch. Pharm. LXXVI, 292; Chem. Gaz. 1851, 141.

Sugar  
Decompo-  
sition by  
lime.

obtained between  $100^{\circ}$  and  $250^{\circ}$ , which Schwarz views as members of a series  $C_m H_{m-3} O_3$  ( $C_{14} H_{11} O_3$ ,  $C_{18} H_{15} O_3$ ,  $C_{20} H_{17} O_3$ , and  $C_{28} H_{25} O_3$ ). Schwarz considers these substances to be  $C_{12} H_9 O + C_n H_n O_2$ , viz.: compounds of a basic oxide with the aldehydes of the acids  $C_n H_n O_4$ . As an argument in favour of this view he regards the fact, that a mixture of these substances, when treated with oxydizing agents, yields such acids (formic, acetic, propionic acids). When the compounds in question are long boiled with a solution of potassa, in such a manner that the vapours condense and flow back again, resins are formed and a very mobile liquid of an agreeable narcotizing odour; the latter has the composition  $C_{12} H_{10} O_2$ ; it produces no acids  $C_n H_n O_4$  when treated with oxydizing agents, but oxalic acid and a volatile oil  $C_{10} H_8 O$ , and yields with concentrated sulphuric or anhydrous phosphoric acids, a volatile oil  $C_{12} H_8$ , boiling at  $180^{\circ}$ .

**Decomposition by Phosphoric Acid.**—Handtke(1) has investigated the decomposition of sugar by phosphoric acid. According to him, anhydrous phosphoric acid does not act upon sugar at the ordinary temperature. A mixture of 1 part of the former with 2 parts of cane-sugar becomes soft, at  $110^{\circ}$  or thereabouts, is rendered brown, and at a somewhat higher temperature dilute formic acid distils, whilst humus-like substances and uncrystallizable sugar remain behind. A mixture of equal parts of sugar and acid becomes brown even at  $90^{\circ}$ , at a higher temperature formic acid and water likewise pass over. The action of aqueous phosphoric acid is similar to that of sulphuric acid, uncrystallizable sugar and humus-like substances being formed, a phospho-saccharic acid could not be obtained.

On the action of bichloride of tin on sugar, comp. "Analytical Chemistry."

**Grape-sugar.**—Pasteur(2) states, that the compound of grape-sugar with chloride of sodium, the crystals of which possess the hexagonal form  $+R.-R.+\frac{1}{2}R$ , crystallizes in the rhombic system, the apparently hexagonal basis having angles of  $120^{\circ} 12'$  and  $119^{\circ} 54'$ ; the faces of the apparently hexagonal pyramid  $+R.-R$  belong to a rhombic pyramid and a brachydiagonal dome, and the appearance of the 6 faces which have been taken for  $+\frac{1}{2}R$  is caused by hemihedrism. Sections cut vertically with the axis of the apparently hexagonal pyramid do not, according to him, exhibit the characteristics of hexagonal crystals in polarized light.

**Mannite.**—T. and H. Smith(3) found (as did previously Widmann and Frickhinger) that the juice of *Leonodon taraxacum* contained mannite; they also observed that mannite is not readily formed in the

(1) Zeitschrift f. Pharmacie, 1850, 37

(2) Ann. Ch. Phys. [3] XXXI, 92

(3) Sill. Am. J. [2] IX, 285, from Proceedings of the Royal Society of Edinburgh, 11, 223

plant, but is generated in the juice by a chemical decomposition of the latter. The same chemists(1) obtained mannite also from the root of *Aconitum napellus*.

Dulcose  
or dulcin

**Dulcose or Dulcin.**—Laurent(2) has examined a sugar-like substance, coming from Madagascar, the origin of which is, however, otherwise unknown. He termed it *dulcose*. When purified by recrystallization from boiling water, it forms distinct crystals, leaving a colourless, uncrystallizable syrup behind. The crystals are colourless and are combinations of the monodimetric system ( $\infty P : \infty P \infty : +P : -P : 0P$ ;  $\infty P : \infty P$  in the clinodiagonal principal section =  $112^\circ$ ;  $\infty P \infty : \infty P = 146^\circ$ ;  $\infty P : -P = 149^\circ 30'$ ;  $0P : -P = 140^\circ$ ;  $\infty P : +P = 135^\circ 30'$ ;  $0P : +P = 115^\circ$ ); they have a slightly sweet taste, similar to mannite. This substance melts at  $190^\circ$ , and solidifies into a crystalline mass a few degrees below that temperature; heated above  $190^\circ$  it loses water (about 9 per cent), remains colourless, and can still crystallize from water; when heated to a still higher degree it is decomposed, similar products of decomposition being formed as in the case of mannite, without any charcoal being left behind. It is but slightly soluble in boiling alcohol. It is not precipitated by basic acetate of lead, is dissolved by dilute solution of potash, without undergoing any change, and forms a thick, colourless syrup which is not precipitated by alcohol; when heated with concentrated sulphuric acid, it forms a sulphuric acid, the baryta-salt of which is soluble and gum-like.—Laurent assigns to crystallized dulcose the formula  $C_{14}H_{17}O_{15} = C_{14}H_{14}O_{12} + 3H_2O$  (found 38.1 and 38.2 per cent of carbon, 7.7 and 7.6 of hydrogen; calculated 38.0 and 7.7); to the baryta-compound the formula  $C_{14}H_{12}Ba_2O_{12} + 14H_2O$  (the water escapes at  $170^\circ$ ); it was obtained by adding baryta-water to a hot and concentrated solution of dulcose, evaporating in a flask and crystallizing. He views dulcose as a substance homologous with grape-sugar ( $C_{12}H_{12}O_{12}$ ), although, according to Soubeiran, the former is not capable of being fermented, and, according to Biot, does not act upon polarized light. By nitric acid dulcose is converted into mucic acid.—In a later notice, Laurent(3) states, that Soubeiran considered dulcose as identical with mannite as far as composition is concerned, that it differs, however, from mannite by its being almost insoluble in boiling alcohol.

Jacquelin(4) has likewise examined this substance, and termed it *dulcin*. According to him, it melts at  $182^\circ$ , giving off a very trifling amount of water (0.002 per cent), and solidifies at  $181^\circ$ ; it begins to be decomposed at  $275^\circ$ , carbonic acid being formed, and

(1) Pharm. J. Trans X, 124

(2) Laur. and Gerh. C. R. 1850, 364, short notice, Compt. Rend. XXX, 41; Institut. 1850, 25; Arch. Ph. Nat. XIII, 226, J. Ph. Chem. XLIX, 403.

(3) Compt. Rend. XXX, 339

(4) Laur. and Gerh. C. R. 1851, 21

Dulcose  
or dulcin.

perhaps also acetic acid and acetone; when heated with hydrated potassa or with potassa-lime, it disengages a large quantity of hydrogen. He observed, farther, that sulphuric acid produces with this substance a conjugate acid, and is of opinion that the hydrochloric acid formed by the action of chlorine upon the aqueous solution at  $40^{\circ}$ , acts in a like manner(1).. He confirmed the statement that this substance is not capable of fermentation, and that it does not act upon polarized light. He found in the crystallized substance from 39.6 to 39.9 per cent of carbon and from 7.6 to 7.8 of hydrogen; after melting 39.7 per cent of carbon and 7.7 of hydrogen, and establishes for it the formula  $C_{10}H_{12}O_{10}$ , according to which the carbon is calculated at 39.5 per cent, and the hydrogen at 7.9 per cent.—Laurent(2) found, on repeating his analysis of the crystallized substance, 39.2 per cent of carbon and 7.6 per cent of hydrogen, and proposes the formula  $C_{14}H_{16}O_{14} = C_{14}H_{14}O_{12} + 2 H_2O$  (this requires 39.6 per cent of carbon and 7.6 of hydrogen); he acknowledges, however(3), that the formula of mannite ( $C_{12}H_{14}O_{12}$ ) also corresponds to these results, and that dulcose may be isomeric with mannite.

**Inosite.**—Scherer(4) has communicated an investigation of a peculiar substance obtained from muscular flesh. If, in the manner stated by him(5), all the baryta be precipitated from the mother-liquor of creatin by means of dilute sulphuric acid, and the liquor when filtered off be subjected to distillation in order to obtain the volatile acids, a residue remains, from which the last portions of the volatile acids, as well as all uncombined lactic acid, can be obtained by shaking with ether. If now the remaining liquid be gradually mixed with strong alcohol, until it becomes turbid, sulphate of potassa separates, and then (after repeating the addition of alcohol), in addition to sulphate of potassa, a substance crystallizing in the form of gypsum. The latter is separated from the sulphate of potassa by being picked out, or by its greater solubility in a small quantity of warm water; it is then recrystallized from as small a quantity of warm water as possible. Scherer terms it *inosite*. It forms monoclinometric crystals, in most cases grouped like a cauliflower, of the composition  $C_{12}H_{16}O_{16} = C_{12}H_{12}O_{12} + 4 H_2O$ , containing consequently 2 equivs. of water more than crystallized grape-sugar; at the ordinary temperature these crystals become opaque, and *in vacuo* over sulphuric acid or at  $100^{\circ}$  they lose 4  $H_2O$ ; after that, they remain unchanged till  $210^{\circ}$ ; they melt at a higher temperature, without decreasing in weight, forming a mass, which becomes crystalline when rapidly cooled, and

(1) This is doubted by Gerhardt (Laur. and Gerh. C. R. 1851, 26).

(2) Compt. Rend. XXXI, 694.

(3) Laur. and Gerh. C. R. 1851, 29.

(4) Ann. Ch. Pharm. LXXIII, 322; J. Pr. Chem. L, 32 (in abstr.); J. Pharm. [3] XVIII, 71.

(5) Annual Report for 1849, III, 368.

when slowly amorphous; it again crystallizes when dissolved in water. Inosite has a sweet taste, is very soluble in water, with difficulty in strong alcohol (from the boiling alcoholic solution it crystallizes on cooling in the form of leaves similar to cholesterin), and is not changed when evaporated with hydrochloric acid, or when boiled with dilute sulphuric acid or with dilute alkalies. Mixed with yeast and water, it does not exhibit the phenomenon of fermentation; with putrid cheese or meat, it forms lactic and butyric acids. Scherer does not decide whether this substance exists as such in the juice of the meat, or whether it is formed from one of its constituents by the action of chemical agents.

**Paramylon.**—In a species of Infusoriæ, *Euglena viridis*, small grains are contained in considerable quantities, resembling the grains of starch; these have been examined by Gottlieb(1). The froth formed by these infusoriæ was mixed with a large quantity of water, strained through a very fine wire sieve, and then from the liquid, which passed through, the fine sand was separated which settled first; the green infusoriæ, next deposited, were extracted with a mixture of alcohol and ether, then with ether; and after that with boiling alcohol of 80° per cent (a green colouring matter, a brown nitrogenous substance and much fat were hereby dissolved); the animals, now of a violet colour, were then treated with a boiling mixture of alcohol and hydrochloric acid, whereby they assumed a yellowish-white colour. During this treatment the integument of many of these animals burst, and the granular contents came out. A separation of the grains from the membranes was attempted to be effected by straining the mixture, suspended in water, repeatedly through calico free from starch; from the liquor, running through, the grains which deposited had a beautifully white colour. They were treated with dilute solution of potassa, in which they dissolved, leaving sand and particles of membrane behind, and from the solution separated by dilute hydrochloric acid in the form of a transparent gelatinous body; by long-continued washing with water the mass could be obtained free from chloride of potassium and hydrochloric acid. From an admixture of a brown substance (formed by the action of potassa on the membrane) it could be freed by being repeatedly dissolved in potassa and precipitated with a mixture of hydrochloric acid and alcohol. From *Eugleniæ* which have been dried at 100°, this substance cannot so easily be obtained pure.—The unchanged grains are white, resembling wheaten starch (only smaller), and can at 100° easily be deprived of adhering water. The substance purified by means of potassa, and dried, forms gum-like, slightly yellow particles which but slowly give off the adhering water; it swells in water without forming a jelly (as is the case when precipitated by hydrochloric acid).

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(1) Ann. Ch. Pharm. LXXV, 51.

Paramy-  
lon.

The substance (the mechanically isolated grains, dried at  $100^{\circ}$ , after deducting the ashes, as well as the purified substance, dried at  $110^{\circ}$ ) has the composition  $C_{12}H_{10}O_{10}$ , and is therefore isomeric with amylon; in reference to this, Gottlieb terms it *paramylon*. It is not soluble in ammonia, even on boiling, is insoluble in water, as well as in dilute acids (in the latter even on boiling). Compounds with bases could not be obtained; Gottlieb considers, however, that the preparation of such compounds is possible. By boiling paramylon with an excess of fuming hydrochloric acid it is (whilst assuming a brown colour) converted into fermentable sugar. The liquor mixed with its bulk of water, and, in order to remove the hydrochloric acid, evaporated to one-half, and then completely freed from hydrochloric acid by means of a solution of silver, produced on inspissation a brownish, sweet syrup which exhibited the deportment of grape-sugar with the copper test, and underwent alcoholic fermentation when mixed with yeast and water.—By heating paramylon to  $200^{\circ}$  it becomes brown without melting; water then dissolves a tasteless, gum-like substance. On treating paramylon with nitric acid a considerable quantity of oxalic acid is formed.

**Wood.**—Cagniard-Latour(1) has found, according to a short notice, that wood of sycamore, oak, birch, box and poplar, freed from hygroscopic water as much as possible, and sealed up in strong glass tubes, in the form of small cylinders, becomes brown at  $360^{\circ}$  or thereabouts, and is then shortly afterwards converted into a black liquor which soon boils, and becomes a solid mass. Under similar circumstances the wood of guaiacum is converted, but with more alcoholity, first into a reddish liquid, and then into a chesnut-brown mass. Guaiacum-wood, powdered, and mixed with half its weight of water, is more readily converted into a liquid, and this into a black, carbonaceous mass, resembling charcoal. Grains of wheat remained solid under these circumstances, and were only carbonized.—According to a second communication(2), Cagniard-Latour obtained, by a similar treatment of old sycamore-wood, mixed with half its weight of water, a substance similar to a fatty coal; of young sycamore-wood, also a fatty (resinous) coal which burned with a smoky flame. In the latter experiments, a bituminous substance, melting at  $100^{\circ}$ , was condensed in those parts of the tube which were less hot.

Mitscherlich(3) has examined the composition of the walls of the vegetable cell, and has first communicated the results on two main constituents of it, viz.: cellulose and suberose.

**Cellulose.**—The paper prepared in Sweden is pure cellulose,

(1) Instit. 1850, 214.

(2) Ibid. 253.

(3) Berl. Acad. Ber. March, 1850, 102; Ann. Ch. Pharm. LXXV, 305; J. Pr. Chem. L, 144; Chem. Gaz. 1851, 61; Instit. 1850, 228.

inasmuch as the contents of the cells are almost completely removed by the mechanical treatment and the process of bleaching: any portion that might have been retained is removed by dilute solution of soda, whereby, however, the cellulose also undergoes a slight change. Paper dried at  $140^{\circ}$  yielded 43.99 per cent of carbon, 6.20 of hydrogen, 49.31 of oxygen, and 0.50 of ashes; paper which had been boiled with a solution of soda of 1.060 spec. grav. for a considerable time (whereby the solution was slightly coloured), contained 45.70 per cent of carbon, 6.24 of hydrogen, 48.79 of oxygen, and 0.27 of ashes (the ashes consisted chiefly of carbonate of lime). From the first analysis, Mitscherlich deduces for cellulose the formula  $C_{12}H_{10}O_{10}$ , which Payen(1) had already proposed; whilst Baumhauer(2) considered  $C_{21}H_{21}O_{21}$  to be more correct. Continued action of the alkalis upon cellulose causes the latter to be coloured blue by iodine; but even on the application of a solution of potassa of such a concentration that hydrogen is given off, this is the only change that takes place, no humus-like substances being formed. By the action of dilute sulphuric acid, cellulose is completely converted into starch and dextrin, without any appreciable secondary products. Nitric acid of 1.20 spec. grav. does not act upon it whilst cold, and but little in the water-bath. By the action of putrid potatoes, cellulose is dissolved; by this action, the cells containing the amylon in sound potatoes are first separated, then their walls dissolved. The same process occurs, according to Mitscherlich, in the potato-disease: the putrefaction of the contents is, therefore, not the disease itself, but only the consequence of it(3). Cellulose is also frequently dissolved in the process of germination, and by the development of a plant, if this take place at the expense of the seed, or of a part of the plant itself.

**Suberose.**—On the composition of suberose, Mitscherlich does not, as yet, give a decided opinion, on account of the difficulty of obtaining it in a pure state. Suberose forms sometimes a thin, amorphous, coherent coating of the whole plant; sometimes it constitutes the uppermost layer of cells of the stem; in the case of the potato, it forms several layers of cellular tissue, which differ from the starch cells situated immediately below, in structure and chemical deportment, and which in the case of boiled potatoes may be peeled off. Suberose is readily distinguished from cellulose by its deportment with acids. Concentrated sulphuric acid acts but slowly on the former; nitric acid, of 1.2 spec. grav., oxydizes it even below  $100^{\circ}$ , and forms at last a series of acids, terminating

(1) Ann. des Sciences Nat. Botan. XI, 21; XIV, 73.

(2) Scheikund. Onderzoek. II, 31, 194; Berzelius' Jahresber. XXIV, 462; XXV, 585.

(3) Comp. J. Liebig's Investigations on some of the Causes of the Motion of the Juices in the Animal Organism, pp. 81, sqq.



**Suberose.** with suberic and succinic acids. After deducting the cellulose, the ashes and the substances soluble in alcohol, the suberous layer of the potato was found to contain 62.30 carbon, 7.15 hydrogen, 27.57 oxygen, 3.03 nitrogen; 100 parts of it yielded, with nitric acid, 6.2 of a fatty acid, soluble in alcohol. Cork of the cork-oak (without any previous treatment, only freed from a brown substance pervading it, and completely desiccated) yielded 65.73 per cent of carbon, 8.33 of hydrogen, 24.54 of oxygen, 1.50 of nitrogen; 100 parts of it yielded, with nitric acid, 39.67 of a fatty acid, and 2.55 of cellulose remained behind. The layer of suberose is not easily permeated by water; potatoes with their skin uninjured may, in consequence of this property, be preserved for a long time (kept for months at a temperature of 30°, they only lost about 3 per cent in weight).

**Proximate Constituents of Plants. Phloridzin.**—Very different formulæ have been proposed for *phloridzin*, although the percentage composition arrived at by several chemists, was very uniform. Stas(1) proposed for the crystallized substance the formula  $C_{32}H_{18}O_{15} + 3HO$ ; Berzelius(2),  $C_{32}H_{19}O_{15} + 3HO$ , or  $C_{10}H_6O_5 + HO$ , or  $C_{42}H_{25}O_{20} + 4HO$ ; Mulder(3),  $C_{21}H_{13}O_{10} + 2HO$ ; Liebig(4),  $C_{42}H_{25}O_{20} + 4HO$ .—Roser(5) has attempted to establish the number of equivs. of carbon contained in 1 equiv. of phloridzin. Crude phloridzin, which, by recrystallization and treatment with animal charcoal, could not be completely freed from a dark extractive substance which was mixed with it, was purified by boiling the aqueous solution with a little gelatin mixing the liquid filtered off from the tough brown mass thus separated, with alum, and neutralizing with lime; the liquor filtered off from the precipitate was then made to crystallize, the tolerably colourless crystals were redissolved, and the solution mixed with a few drops of basic acetate of lead, when the impurities are first precipitated; the crystals of phloridzin obtained from the solution, acidulated with some acetic acid, were several times recrystallized, and exhibited on analysis the composition already known from former investigations (53.95 per cent of carbon, and 6.17 per cent of hydrogen). For the purpose of establishing the formula of phloridzin, Roser took advantage of its decomposition by dilute sulphuric acid, whereby sugar and phloretin are formed. The quantity of sugar formed from 0.6 to 1.0 grm. of dried phloridzin by very dilute sulphuric acid, increased until the fourth day, after which it

(1) Ann. Ch. Phys. [2] LXIX, 367; Berzelius' Jahresber. XIX, 523.

(2) Jahresber. XIX, 524, 526, 535.

(3) J. Pr. Chem. XVII, 300; Berzelius' Jahresber. XIX, 522.

(4) Ann. Ch. Pharm. XXX, 217.

(5) Ann. Ch. Pharm. LXXIV, 178.

again diminished; it was determined by a graduated alkaline solution of protoxide of copper; neither phloridzin nor phloretin do act upon this solution. The quantity of sugar thus formed amounted, in 8 experiments, to from 40·3 to 42·8 per cent of the dried phloridzin, mean 41·8 per cent. According to Liebig's formula, 1 equiv. of phloridzin,  $C_{42}H_{25}O_{20}$ , yields 1 equiv. of sugar,  $C_{12}H_{12}O_{12}=41·2$  per cent; according to the formula of Stas, 1 equiv. of phloridzin,  $C_{32}H_{18}O_{15}$ , gives  $\frac{2}{3}$  of an atom of sugar,  $C_8H_8O_8=36·4$  per cent. A nearer coincidence with Liebig's formula is also obtained by determining the amount of phloretin formed in this decomposition; this substance should contain 30 equivs. of carbon, and its formula, according to the analysis of Stas, is  $C_{30}H_{15}O_{10}$ ; from 100 dried phloridzin 62·9 phloretin should be formed, and Roser found, in 9 experiments, from 59·2 to 61·2, mean 60·5; according to Stas' formula for phloridzin, 66·1 per cent of phloretin should be formed.—Strecker(1) has shown that, by recalculating the former analyses for the correct atomic weight of carbon, the following formulæ agreed very satisfactorily with the results of the analyses: for phloridzin,  $C_{42}H_{24}O_{20} + 4 HO$ ; for phloretin,  $C_{30}H_{15}O_{10}$ ; for phloridzein,  $C_{42}H_{30}N_2O_{26}$ : the formation of the latter he explains by the equation,  $C_{42}H_{28}O_{24} + 2NH_3 + 6 O \Rightarrow C_{42}H_{30}N_2O_{26} + 4H_2O$ .—Strecker has farther shown, that the near relation formerly assumed between phloridzin and salicin does not in reality exist; the latter may certainly split into grape-sugar, and a second substance (saligenin), by taking up 2 equivs. of water; but saligenin does not exhibit a deportment analogous to that of phloretin.

**Aloin.**—T. and H. Smith(2) obtained from an aqueous extract of Barbadoes aloes, prepared cold and concentrated *in vacuo*, a crystalline body which they consider as the purgative principle of aloes, and to which they give the name of *aloin*. They are of opinion that other sorts of aloes also contain this body, such as the aloes of Socotra and of the Cape, but that it is mixed therein with such an amount of other substances, that its crystallization is impeded or prevented.—Stenhouse(3) has submitted aloin to a chemical examination. He purified it by pressure between bibulous paper, and recrystallization from warm water: the solution must not be heated beyond  $65^\circ$ , because oxydation ensues at a higher temperature. On cooling the hot alcoholic solution, aloin crystallizes in small, star-like grouped needles. It is neutral; its taste is at first sweetish, then bitter; it is little soluble in cold water and alcohol, more so when heat is applied, forming pale yellow solutions; it is

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Phloridzin.

(1) Ann. Ch. Pharm. LXXIV, 184.

(2) Chem. Gaz. 1851, 107, from Monthly Journ. of Medical Science, Feb. 1851.

(3) Phil. Mag. [3] XXXVII, 481; Ann. Ch. Pharm. LXXVII, 208; J. Pr. Chem. LIII, 149.

Aloin.

dissolved by the caustic alkalies and their carbonates; the solutions are orange-coloured, and become rapidly darker in consequence of oxydation; when boiled with alkalies or with strong acids, it is rapidly converted into a dark brown resin. The solutions are not precipitated by neutral metallic salts; a concentrated solution produces a deep yellow precipitate with a concentrated solution of basic acetate of lead, becoming rapidly brown in the air.—Stenhouse found the composition of aloin, dried *in vacuo* =  $C_{34}H_{19}O_{15}$ , and of aloin, dried at  $100^{\circ}$  =  $C_{34}H_{18}O_{14}$ . With cold, fuming nitric acid, it appears to form a nitro-compound, by digestion with strong nitric acid, it is converted into chrysamic acid, without a trace of picric acid being formed; by boiling it with chlorate of potassa and hydrochloric acid, no chloranil is formed. When subjected to dry distillation, it produces a volatile oil of a somewhat aromatic odour, and a considerable quantity of a resinous substance. When heated to  $100^{\circ}$  for upwards of six hours, it loses continually in weight, and is converted into a brown resin; this is more rapidly effected at  $150^{\circ}$ , whereby it melts.—Bromine produces, with an aqueous solution of aloin, a yellow precipitate, *bromo-aloin*, whilst hydriobromic acid is formed at the same time. Bromo-aloin crystallizes from alcohol in yellow, star-like grouped needles, which are, when dried *in vacuo*,  $C_{34}H_{15}Br_3O_{14}$ . A similar precipitate, obtained by the action of chlorine, could not be obtained in a crystalline form.—Stenhouse attempted in vain to prepare aloin from the aloes of the Cape and of Socotra. In conclusion, Stenhouse points out the difference of aloin from Robiquet's aloetin(1).

**Apin.**—Biacconot(2) found in parsley a peculiar substance, which he termed *apin*. This body has been the subject of recent investigations by Planta and W. Wallace(3). The apin is not pure when prepared by Biacconot's method, viz.: by boiling fresh parsley with water, filtering through linen, washing the jelly, formed on cooling, with hot water, pressing, and drying. In order to purify it, it was repeatedly boiled with alcohol, the jelly formed, on cooling the alcoholic extracts, was dissolved in warm water, the alcohol distilled off, the green mass remaining repeatedly pressed, after being previously moistened with alcohol, and finally repeatedly digested and boiled with ether. (Apin, chlorophyll, and a vegetable wax mixed with it, are soluble in boiling alcohol; apin is insoluble in ether). Apin dried at  $100^{\circ}$  is a soft, white powder, without taste and odour; its composition corresponds to the formula  $C_{24}H_{14}O_{13}$  (it contained but little ashes, 0.15 to 0.62 per cent). It is soluble

(1) J. Pharm. [3] X, 167, 241, Berzelius' Jahresber. XXVII, 490.

(2) Ann. Ch. Phys. [3] IX, 250, Berzelius' Jahresber. XXIV, 532.

(3) Ann. Ch. Pharm. LXXIV, 262, Phil. Mag. [4] I, 212; J. Pr. Chem. LII, 390; Chem. Gaz. 1850, 377; Instit. 1851, 143.

in 8500 parts of cold, and in much less hot water; a solution of 1 apiin in 1587 parts of water forms a jelly, when cooled to  $0^{\circ}$ . It dissolves in 389 parts of cold, and in much less hot alcohol. The reaction mentioned by Braconnot, that apiin strikes a blood-red colour with sulphate of protoxide of iron, even when its solution is very dilute, has been confirmed by Plancha and Wallace. Neutral metallic oxides produce no precipitates in solutions of apiin: only the alcoholic solution of acetate of lead causes, in an alcoholic solution of apiin, a yellow precipitate containing a variable amount of lead. By protracted boiling apiin with water, and replacing the evaporated water, the solution loses its property of forming a jelly, and if now cooled, a light, flocculent, almost colourless precipitate separates, which, dried at  $100^{\circ}$ , weighs more than the original apiin, and which has the composition  $C_{24}H_{16}O_{15}$ ; it exhibits the same reaction with sulphate of protoxide of iron as apiin. On boiling apiin for some time (from half-an-hour to twenty-four hours) with very dilute sulphuric acid, the liquor no longer forms a jelly on cooling, but deposits a whitish, flocculent precipitate, which, dried at  $100^{\circ}$ , is  $C_{24}H_{10}O_9$ ; it is less soluble in boiling water than apiin. The formation of fermentable sugar, by boiling apiin with dilute sulphuric acid, could not be observed; (there is, however, after removing the sulphuric acid, a sweetish syrup formed, which separates suboxide of copper when boiled with the potasso-tartrate of copper). By boiling with dilute hydrochloric acid, a similar body of a like composition is formed which, however, is more easily soluble in boiling water. From the solution of apiin in cold concentrated sulphuric or hydrochloric acids, water precipitates a flocculent, yellow body,  $C_{24}H_{12}O_{11}$ , less soluble in water, and less apt to gelatinize, than apiin. Alkalies dissolve apiin without changing it. Chlorine gas produces, in a solution of apiin, a dirty yellow, chlorinetted precipitate. Apiin dried at  $100^{\circ}$  absorbs from 5.11 to 5.13 per cent of dry hydrochloric acid gas, assuming thereby a yellow colour which disappears on heating. Crude apiin, boiled with nitric acid, forms picric and oxalic acids; the formation of these acids could not be observed when pure apiin was used. Heated with binoxide of manganese and sulphuric acid, apiin forms carbonic, formic, and acetic acids.

**Saponin.**—A communication by Le Beuf (1) on saponin, contains no new information, except perhaps the proposal to use water containing saponin to keep substances, insoluble in water, in a state of suspension.

**Peucedanin.**—Concerning the uncertainty in Bothe's results on the substances derived from peucedanin, which have been discussed in last year's Report, p. 328, sqq., this chemist published a reply (2), in which he adheres to the formulæ previously adopted by him.

(1) *Compt. Rend.* XXXI, 652; *J. Pr. Chem.* LI, 471. (2) *J. Pr. Chem.* I., 381.

**Scillitin.**

**Scillitin.**—In experiments to prepare scillitin according to the method described by Lebourdais(1), Bley(2) obtained a bitter substance, crystallizing in flexible needles; he treated the extract of the squills only in the cold with animal charcoal, and evaporated the alcoholic extract of the charcoal at 24°. On application of a higher temperature, no crystals made their appearance.

**Githagin (Agrostemmin).**—From the seed of the corn-cockle (*Agrostemma githago*), Scharling(3) has prepared a poisonous substance, *githagin*, the identity of which with the agrostemmin of Schulze(4) is as yet undecided. Scharling obtained the body described by him by repeatedly boiling the ground seed previously freed from fat by means of ether, with alcohol of 84° Tr. The filtrate is evaporated to dryness, and treated with hot alcohol of 92° Tr.; when, on cooling, impure githagin separates, of which a farther portion is precipitated from the supernatant liquor by absolute alcohol. The aqueous solution of the impure substance is first treated with acetate of lead, and the liquor filtered off from the precipitate mixed with basic acetate of lead, when a compound of githagin and protoxide of lead is deposited, which is suspended in water, and decomposed by sulphuretted hydrogen. The aqueous solution is evaporated, until a gelatinous substance separates from it, when it is filtered, and the filtrate completely brought to dryness; or the concentrated solution is precipitated by strong alcohol. The body thus obtained resembles gum-arabic or starch; it is without odour, insoluble in absolute alcohol or ether, soluble in weaker alcohol and in water. The solution froths when shaken, has a disagreeable odour, and a taste which becomes gradually burning: in the eye, it produces a painful dilatation of the pupil. Concentrated sulphuric acid imparts a red colour to githagin, which gradually becomes bluish-green; nitric acid converts it into oxalic acid. By dry distillation, githagin yields some ammonia. Its aqueous solution is not precipitated by bichloride of platinum, nor by protochloride of mercury, nor tannic acid, but by basic acetate of lead. 10 grains of githagin killed a rabbit in five minutes, 20 grains a cat, but not for eight days.

**Colocynthin.**—W. Bastick(5) communicates the following method for preparing colocynth. The pulp of colocynth is repeatedly treated with cold water until it has lost its bitter taste, and the extract, after being heated to boiling, is precipitated with acetate

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(1) Annual Report for 1847 and 1848, II, 109.

(2) Arch. Pharm. [2] LXI, 141.

(3) From Oversigt o. d. K. Danske Vidensk. Selskabs Forhandl. No. 5—6, 1849, 96 in Ann. Ch. Pharm. LXXIV, 351; Chem. Gaz. 1850, 355.

(4) Annual Report for 1847 and 1848, I, 497.

(5) Pharm. J. Trans. X, 239.

of lead. When cold, the mass is filtered; from the filtrate the oxide of lead is removed by dilute sulphuric acid, and the acetic acid by boiling(?); the clear solution is then evaporated nearly to dryness. Strong alcohol now dissolves colocynthin, which is left behind in a pure state on evaporating the alcoholic solution. Colocynthin thus obtained is reddish-brown, resinous, melts at a gentle heat, and possesses neither basic nor acid properties. It dissolves in nitric acid of 1.45 spec. grav., whilst red vapours are given off and a pale yellow, uncrystallizable acid is formed, which is precipitated by water, and tastes less bitter than colocynthin.

Colocyn-  
thin.

**Vegetable Chemistry. Assimilation of Nitrogen and Decomposition of Carbonic Acid.**—Ville(1) has made an investigation on the assimilation of the nitrogen of the atmosphere by plants, and on the influence of ammonia on vegetation; these experiments have, however, as yet only been published in abstract. He made the plants grow in closed cases, renewing the air daily; the plants took root in a mixture of sand and brick-powder, to which 5 per cent of the ashes of the same plant were added. 5 to 7 per cent of carbonic acid were added to the air; the amount of ammonia contained in it was determined previous to its being admitted into the case, and after its replacement by other air. Ville states that the amount of ammonia in air was not changed by plants growing in it; and that, moreover, this amount was insufficient to furnish all the nitrogen which was assimilated by the plants; the free nitrogen of the atmosphere, he says, was assimilated in a direct manner. Addition of ammonia to the atmosphere, however, still exerted a favourable influence on the development of plants, especially the cereals.

Cloëz and Gratiolet(2) have communicated the results of their experiments on the vegetation of aquatic plants (species of *Potamogeton*, *Najas*, *Ceratophyllum*, *Myriophyllum* and *Conserve*). These plants rapidly decompose carbonic acid with disengagement of oxygen in direct solar light, but scarcely in diffused light, and not at all in the dark; this decomposition proceeds best under dim colourless glass; less under yellow, or transparent colourless, or red, green and blue glass, diminishing in intensity in the order just named. On raising the temperature, commencing with 4°, the decomposition of the carbonic acid does not begin below 15°, and appears to arrive at its maximum at 30°; on decreasing it, commencing with 30°, this decomposition continues below 15°, and ceases completely only at 10°. If the water, in which the plants live, do not contain any

(1) Compt. Rend. XXXI, 578; J. Pr. Chem. LII, 60.

(2) Compt. Rend. XXXI, 626; Instit. 1850, 347; J. Pr. Chem. LII, 275; more detailed in Ann. Ch. Phys. [3] XXXII, 41.

Vegetable  
chemistry.

Assimilation of nitrogen and decomposition of carbonic acid.

absorbed atmospheric air, but only carbonic acid, the disengagement of oxygen ceases after a few days, and the green colour of the plants becomes much less intense; in this case nitrogen(1) is also given off at first along with the oxygen, so that the plant subjected to this experiment contains at last less nitrogen than when living in water containing air, whereby the loss of nitrogen, eliminated during the decomposition of the carbonic acid by the transmutation of the organs of the plant, is replaced by assimilation of nitrogen from the atmosphere. The least addition of ammonia as ammoniacal salts to the water in which the plants vegetated proved injurious, and checked the decomposition of the carbonic acid.

J. H. and M. G. Gladstone(2) have made some experiments on the growth of plants in various atmospheres. A *Viola tricolor* lived twenty-four days in an atmosphere of hydrogen to which 5 per cent of carbonic acid had been added; another lived longer in the ordinary atmosphere under the same circumstances. Germinating onions were brought into atmospheres of carbonic acid, carbonic oxide, marsh-gas, atmospheric air with 8 per cent of light carbonated hydrogen and of ordinary atmospheric air; in the first two gases the germination was instantaneously checked, the carbonated hydrogen however appeared to act favourably. In pure nitrogen a *Viola tricolor* died soon; a grass plant lived in it for one month. In a mixture of 2 hydrogen and 1 oxygen a *Viola* lived for upwards of fourteen days.

According to Daubeny(3) the sprinkling with water containing little carbonic acid (from 1 to 3 per cent) acts beneficially on the development of ferns; the sprinkling with water containing more carbonic acid proved unfavourable.

On the action of the constituents of soil on the development of plants, see *Agricultural Chemistry*.

**Scilla maritima.**—Wittstein(4) has collected the previous examinations of *Scilla maritima* and added experiments of his own, concerning which we must refer to the original. Respecting scillitin contained in the root, comp. p. 372.

• **Lucerne.**—Bernays(5) thinks he has found in the roots of lucerne (*Medicago sativa*) a peculiar resin, *Medicago-resin*.

**Root of *Ulicco tuberosus*.**—Mulder(6) has communicated experiments (made by Scharlée) on the root of *Ulicco tuberosus*; the fresh root contains in the mean 87.9 per cent of water; that dried at 120°, 2.6 per cent of nitrogen, 44.5 per cent of carbon and 6.2 per cent of hydrogen. The solid substance of the root consists of 3.1 (chiefly

(1) In this manner the water becomes such, as contains the constituents of atmospheric air absorbed.

(2) Chem. Gaz. 1850, 342; Instit. 1850, 335.

(3) Instit. 1850, 375.

(4) Repert. Pharm. [3] IV, 189.

(5) Repert. Pharm. [3] VI, 329.

(6) Scheik. Onderzoek. V, 7, Stuk, 422; Arch. Pharm. [2] LXV, 184 (in abstr.).

crystallizable) fat; 29.4 fruit-sugar and extractive matter with resin; 4.0 gum; 33.3 amylon; 11.9 solid albumin; 18.3 cellulose and other insoluble parts. The ashes (9.1 to 9.7 of the dried root) contain lime, sesquioxide of iron, little magnesia, soda, little potassa, carbonic acid, sulphuric acid, much phosphoric acid and chlorine, and little silicic acid.

**Guaicuru-root.**—Lenoble(1) examined a root growing in Uruguay (South America) and called there *guaicuru-root*, and found it to contain as active principles: tannic acid, resin, red colouring matter and an ammoniacal salt.

**Tubers of *Oxalis crenata*.**—Lassaigne(2) investigated yellow and white tubers of *Oxalis crenata*, and found in a yellow tuber 83.0 (in a white one 81.8) of water; 12.5 (13.7) of amylon; 0.6 (0.5) of legumin; 2.8 (3.0) of nitrogenous extractive matter and alkaline salts; 0.2 (0.2) of pectin; 0.8 (0.8) of cellulose; 0.1 of orange-coloured colouring matter.

**Barks.**—Winkler(3) has made some communications on a bark, as yet little known, and containing chinovic acid; he terms it *China pseudo-rubra*; Buchner, Sen.(4) considers it to be identical with *Cortex chinæ novæ brasiliensis*. Du Mênil(5) has described some experiments with cinnamon-cassia.

**Faham-leaves.**—Gobley(6) has examined the odoriferous principle of faham-leaves (of *Angræcum fragrans*); he obtained it by extracting the leaves with alcohol, evaporating the extract, treating the residue, mixed with water, by means of ether, evaporating the ethereal solution, and extracting the residue with boiling water, when on cooling the aqueous solution, the substance was deposited in crystals. According to him, this body is *cumarin*, the same substance which has been found in Tonka-beans, *Melilotus* and *Asperula odorata*. The crystals, considered by Gobley to be *cumarin*, melted at 120°, whilst the melting-point of *cumarin* is stated to be 50°; according to Gobley, however, *cumarin* prepared from *melilotus* exhibits also a melting-point of 120°. He found the crystalline substance of faham-leaves to contain 76.12 per cent of carbon and 4.12 of hydrogen, which certainly approaches to the composition given by Guillemette(7) (Gobley says Henri) for *cumarin* from *melilotus*, but which differs considerably from the analysis of Delalande and Bleibtreu, according to which *cumarin*, from tonka-beans and from *asperula odorata*, possesses the formula  $C_{18}H_6O_4$ , requiring 73.97 per cent of carbon and 4.11 of hydrogen(8).

**Yerba-mate.**—Lenoble(9) has examined the *Yerba-mate*, or the

(1) J. Pharm. [3] XVII, 200.

(2) J. Chim. Méd. [3] VI, 198.

(3) Repert. Pharm. [3] IV, 206.

(4) Repert. Pharm. [3] IV, 207.

(5) Arch. Pharm. [2] LXII, 27.

(6) J. Pharm. [3] XVII, 348; J. Pr. Chem. L, 286; Chem. Gaz.

(7) J. Pharm. [2] XXI, 172; Berzelius' Jahresber. XVI, 228.

(8) Comp. Bleibtreu in Ann. Ch. Pharm. LIX, 177.

(9) J. Pharm. [3] XVIII, 199.



Yerba-  
mate.

**Paraguay-tea** (the dried leaves of *Psoralea glandulosa*, L., or *Ilex paraguensis*, St. Hilaire); he mentions the following substances as constituents; tannic acid, chlorophyll, vegetable wax, albumin, volatile oil, gummy extractive matter, and a crystallizable, nitrogenous body, which he terms *psoraleine*. Lenoble does not mention *Theine*, which Stenhouse(1) has found in the Paraguay-tea, and with which the so-called *psoraleine* is most likely identical.

**Berries of *Myrtus communis*.**—Riegel(2) has examined the berries of *Myrtus communis*, and found them to contain chlorophyll, a green soft resin, volatile oil (occurring also in the leaves), fatty oil, tannin, sugar, citric and malic acids, mucilage, humus-like substances, a little potassa and lime.

**Secretion of *Mesembryanthemum Crystallinum*.**—Völcker(3) has found in the aqueous secretion of the leaves and the stem of the ice-plant (*Mesembryanthemum crystallinum*, L.), albumin, oxalic acid, chloride of sodium, potassa, magnesia and sulphuric acid.

**Proximate Constituents of the Animal Body. Albumin.**—Paget(4) has confirmed Hunter's observation, that a fresh hen's egg is more slowly frozen than one which has been frozen and afterwards thawed. He found that rotten eggs, or eggs the contents of which had been acted on mechanically or electrically, froze easier (even at 0° C.) than fresh eggs, which did not freeze at -9°. Hunter's opinion that the resistance to freezing must be ascribed to in-dwelling vital power, however, is not adopted by Paget, who rather believes that everything which makes the albumen in an egg more fluid than it is when fresh, also makes it freeze more easily.

J. B. Edwards(5) and Kendall(6) deny that albumin combines chemically with arsenious acid, and that the poisonous action of this latter substance depends on its combination with the albumen of the organs of the body, rendering them incapable of supporting life.—Edwards found that, when a solution of 1 part of arsenious acid was mixed with 100 parts of albumin (from hens' eggs) and coagulated by heat, much arsenic still remained dissolved in the fluid. By washing the coagulum with water (whereby the coagulum was broken up) all the arsenic could be removed. The same thing happened with the coagulum which formed in blood on the addition of some arsenious

(1) Ann. Ch. Pharm. XLV, 368; XLVI, 228.

(2) Arch. Pharm. [2] LXI, 161.

(3) Phil. Mag. [3] XXXVI, 377; J. Pr. Chem. L, 240; Instit. 1850, 215.

(4) Phil. Trans. for 1850, I, 221; Chem. Gaz. 1850, 277 (in abstr.); Ann. Ch. Pharm. LXXXVI, 363.

(5) Chem. Soc. Qu. J. III, 14; Pharm. J. Trans. IX, 524; Schmidt's Jahrb. d. Medicin, LXVII, 8.

(6) Pharm. J. Trans. IX, 526; Schmidt's Jahrb. d. Medicin, LXVII, 8.

acid.—Kendall found that a solution of albumin at a temperature which did not cause it to coagulate, is not precipitated by arsenious acid, and, on the other hand, that arsenious acid was not made insoluble by means of albumin.

Desor's(1) opinion that a substance, *biogen*, differing from albumin, is contained in the eggs of the lower animals, is opposed by C. Girard(2). The contest is not sufficiently chemical to allow of particular mention here.

Urea.—Wittstein(3) states that pure urea dissolved in water, and boiled in open vessels is decomposed, carbonate of ammonia being formed; and to avoid loss, he advises that such a solution should be evaporated below the boiling temperature.—Boussingault(4) found, on the contrary, that a solution of 1 part urea in 100 parts water, by evaporation at a boiling temperature to one half its volume, gave scarcely a trace of ammonia, (provided care was taken that the glass above the level of the fluid and the urea which adhered to it were not heated to a higher temperature). If the fluid was concentrated to  $\frac{1}{5}$  of the original volume, then ammonia was evolved, but only because the fluid became so ropy that some portions became heated over 100°. He found that when a solution of 1 part of urea in 100 water was boiled with magnesia or lime, ammonia was evolved. If such a solution was kept continuously heated with lime to 40°, whilst atmospheric air was passed through it, no sensible quantity of ammonia was formed. The same was the case when a solution of urea with lime or carbonate of soda was evaporated between 45° and 50° *in vacuo*.

Huraud(5) has investigated a substance called by Baud hydroferrocyanate of potassa and urea, which he also recommends as a substitute for sulphate of quinine. He found that when a solution containing ferrocyanide of potassium and urea is allowed to crystallize in successive portions the ferrocyanide of potassium crystallizes with very different quantities of urea. (He states that he found even as much as 41 per cent). This exists only intermixed, and not in a state of chemical combination in definite proportions.

**Animal Chemistry. Roe of Carp.**—Gobley(6) has examined the composition of the roe of the carp, and has obtained the following results. It greatly resembles the yolk of hens' eggs(7). The alkaline albumin which generally surrounds the yolk appears to be absent.

(1) Annual Report for 1849, III, 356.

(2) Sill. Am. J. [2] IX, 399.

(3) Repert. Pharm. [3] VI, 207.

(4) Ann. Ch. Phys. [3] XXIX, 472; J. Pr. Chem. LI, 281.

(5) J. Pharm. [3] XVIII, 411.

(6) J. Pharm. [3] XVII, 401; XVIII, 107.

(7) See Gobley's investigation in Annual Report for 1847 and 1848, II, 146.

Animal  
chemis-  
try.

Roe of  
carp.

The albuminous substance which is contained in it, the *paravitellin*, has the properties and the composition of the vitellin. As in the yolk, so here, there are two substances: a fatty oil and an adhesive infusible substance. The fatty oil, which is present only in small quantity, consists of olein and margarin. It contains no sulphur or phosphorus. The adhesive substance, which composes by far the greater part of the fat of the roe of the carp, is a compound body containing phosphorus. It consists of cholesterin and two peculiar substances, *lecithin* and *cerebrin*, which are also found in the yolk of hens' eggs. The cholesterin is identical in composition and properties with that contained in the yolk or in gall-stones. The lecithin is the constituent of the hen's egg and carp's roe which contains phosphorus. It is a neutral substance which, when acids or alkalis are present, most readily gives as the products of decomposition in water or alcohol, oleic and margarinic acid and phosphoglyceric acid. It does this even when the action of the oxygen of the air is excluded. The cerebrin is a neutral nitrogenous substance which melts at a high temperature, and swells up like starch when mixed with water. The roe of the carp, when boiled with water, yields an acid liquid, which is said to become more acid on addition of alcohol. This acid reaction Goble ascribes to the presence of lactic acid, or a similar acid. A considerable quantity of the substance which Berzelius has called extract of flesh is contained in the roe of the carp. There seem to be two colouring matters present, as is the case in the yolk of the egg. One is red and contains iron analogous to the colouring matter of the blood; the other is yellow, and perhaps is analogous to the yellow colouring matter of the blood or the bile. The average composition of the roe of the carp is:

|                    |           |        |                                  |        |
|--------------------|-----------|--------|----------------------------------|--------|
| Water              | . . . . . | 64.080 | Chloride of sodium and potassium | 0.447  |
| Paravitellin       | . . . . . | 11.030 | Sulph. and phosph. of potassa    | 0.037  |
| Olein and margarin | . . . . . | 2.574  | Phosph. of lime and magnesia     | 0.292  |
| Cholesterin        | . . . . . | 0.266  | Extract of flesh                 | 0.389  |
| Lecithin           | . . . . . | 3.045  | Membranous substance             | 14.530 |
| Cerebrin           | . . . . . | 0.205  | Colouring-matter, traces of iron |        |
| Sal-ammoniac       | . . . . . | 0.042  | &c.                              | 0.033  |

**Ash of White and Yolk of Hens' Eggs.**—Poleck, who formerly(1) made the analyses of the inorganic constituents of albumen and yolk of egg, according to H. Rose's older method, has repeated the analyses according to the same method(2). The watery extract from the carbonized mass of 713.285 grms. of egg albumen (423.706 yolk) gave 3.916 (3.502) grms. of the percentage composition A. The extract with hydrochloric acid gave 0.3971 (0.3651) grms. of the composition B. The residue of carbon

(1) Annual Report for 1849, III, 355.

(2) Annual Report for 1847 and 1848, II, 237; Annual Report for 1849, III, 413.

gave 0.2395 (2.589) grms. ash having the composition C. From which the composition of the total ash (0.65 per cent of egg albumen, and 1.52 per cent of the yolk) is calculated and given under D. As this calculation was not rightly made from the former analysis, Poleck has again repeated and corrected it. This new version of the former analyses is given under E.

Ash of  
white and  
yolk of  
hens' eggs

|                                  | Albumen. |       |       |       |       | Yolk. |       |       |       |       |
|----------------------------------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                  | A.       | B.    | C.    | D.    | E.    | A.    | B.    | C.    | D.    | E.    |
| Chloride of potassium . . . .    | 48.00    | —     | —     | 41.29 | 42.17 | —     | —     | —     | —     | —     |
| Chloride of sodium . . . .       | 10.65    | —     | —     | 9.16  | 14.07 | —     | —     | —     | —     | —     |
| Soda . . . . .                   | 23.05    | 20.33 | 27.30 | 24.04 | 16.09 | 6.32  | —     | 4.23  | 5.12  | 6.57  |
| Potassa . . . . .                | —        | 12.85 | 23.60 | 2.36  | 1.15  | 10.41 | —     | 8.19  | 8.93  | 8.05  |
| Lime . . . . .                   | —        | 12.46 | 12.32 | 1.74  | 2.79  | 13.32 | 20.68 | 9.54  | 12.21 | 13.28 |
| Magnesia . . . . .               | —        | 14.90 | 5.17  | 1.60  | 3.17  | 1.77  | 2.11  | 2.46  | 2.07  | 2.11  |
| Sesquioxide of iron . . . .      | —        | 2.14  | 5.01  | 0.44  | 0.55  | 1.21  | 4.52  | 1.35  | 1.45  | 1.19  |
| Hydrated phosph. acid* . . . . . | —        | —     | —     | —     | —     | —     | —     | 14.29 | 5.72  | —     |
| Phosphoric acid . . . . .        | 1.32     | 27.60 | 25.44 | 4.83  | 3.79  | 66.75 | 72.72 | 58.56 | 63.81 | 66.70 |
| Carbonic acid . . . . .          | 12.63    | 8.47  | —     | 11.60 | 17.52 | —     | —     | —     | —     | —     |
| Sulphuric acid . . . . .         | 3.06     | —     | —     | 2.63  | 1.32  | —     | —     | —     | —     | —     |
| Silica . . . . .                 | 0.36     | 1.25  | 0.46  | 0.49  | 2.04  | —     | —     | 1.38  | 0.55  | 1.40  |

\* HO, PO<sub>5</sub>.

H. Rose(1) communicates analyses of the ash of albumen and yolk of eggs, which were made by R. Weber; first, according to H. Rose's older method(2); and, secondly, by treating the substance previous to its being burnt with water and hydrochloric acid, and afterwards burning the residue and reducing it to ash. In hard-boiled eggs, the proportion of the yolk to the white is as 35.6 to 64.6. After both were dried at 100°, the proportion was as 66.2 to 33.8. The coagulated albumen lost 86.86 per cent of water by drying at 100°; the yolk lost 50.62 per cent. By the first method of analysis, the carbonized mass from 44.21 grms. of albumen, dried at 100°, gave to water 2.036 grms. of the percentage composition A; afterwards, it gave to hydrochloric acid 0.233 grms. having the composition B; the residue gave 0.099 grms. ash of the composition C; whence the composition of the total ash (5.35 per cent of the albumen dried at 100°) is calculated, and given under D. By the second method, 498 grms. of coagulated albumen gave to water 2.778 grms. of incombustible substance of the composition A; to dilute hydrochloric acid, 0.644 grms. of the composition B; and the residue contained 0.102 grms. ash of the composition C; whence the composition of the total ash (5.38 per cent of albumen, dried at 100°) is calculated under D.

(1) Pogg. Ann. LXXIX, 398.

(2) Annual Report for 1847 and 1848, II, 237; Annual Report for 1849, III, 413.

Ash of  
white and  
yolk of  
hens' eggs.

|                     | After the first method. |       |       |       | After the second method. |       |       |       |
|---------------------|-------------------------|-------|-------|-------|--------------------------|-------|-------|-------|
|                     | A.                      | B.    | C.    | D.    | A.                       | B.    | C.    | D.    |
| Chloride of sodium  | 44.40                   | —     | —     | 38.47 | 49.71                    | —     | —     | 39.30 |
| Potassa             | 29.07                   | 8.16  | 8.09  | 26.34 | 26.96                    | 32.14 | 14.70 | 27.66 |
| Soda                | 7.12                    | 18.88 | 14.14 | 8.64  | 5.36                     | 39.28 | 22.56 | 12.09 |
| Lime                | —                       | 15.62 | 13.13 | 2.04  | 0.61                     | 12.11 | 6.86  | 2.90  |
| Magnesia            | —                       | 18.88 | 28.28 | 3.06  | 0.61                     | 11.33 | 4.90  | 2.70  |
| Sesquioxide of iron | —                       | 1.71  | 4.04  | 0.34  | —                        | 2.17  | 4.90  | 0.54  |
| Phosphoric acid     | 0.54                    | 35.20 | 26.26 | 5.06  | 1.98                     | 2.97  | 36.28 | 3.16  |
| Sulphuric acid      | 1.62                    | —     | —     | 1.40  | 2.16                     | —     | —     | 1.70  |
| Carbonic acid       | 16.20                   | —     | —     | 14.05 | 12.24                    | —     | —     | 9.67  |
| Silica              | 0.14                    | 2.15  | 6.06  | 0.60  | —                        | —     | 9.80  | 0.28  |

By the first method, the carbonized mass from 191.80 grms. of yolk gave to water 0.750 grms., having the percentage composition A; it gave to hydrochloric acid 0.347 grms. of the composition B; the residue gave 1.506 grms. of ash of the composition C; hence the composition of the total ash (2.47 per cent of the yolk, dried at 100°) is calculated and given under D. By the second method, 320 grms. of yolk gave to water 1.390 grms. of incombustible substance of percentage composition A; it gave to dilute hydrochloric acid 1.144 grms. of the composition B; and the residue contained 0.414 grms. of ash, having the composition C; hence the composition of the total ash (the amount of which by this method was 2.74 per cent of the yolk, dried at 100°) is calculated under D.

|                     | By the first method. |       |       |       | By the second method. |       |       |       |
|---------------------|----------------------|-------|-------|-------|-----------------------|-------|-------|-------|
|                     | A.                   | B.    | C.    | D.    | A.                    | B.    | C.    | D.    |
| Chloride of sodium  | —                    | —     | —     | —     | 28.41                 | —     | —     | 9.12  |
| Potassa             | 9.60                 | 10.09 | 7.70  | 8.60  | 26.76                 | 3.40  | 3.38  | 10.90 |
| Soda                | 6.66                 | 8.93  | 4.44  | 5.70  | —                     | 0.91  | 5.80  | 1.08  |
| Lime                | 12.53                | 9.80  | 11.29 | 11.50 | 6.47                  | 19.52 | 1.45  | 13.62 |
| Magnesia            | 4.86                 | 2.30  | 1.40  | 1.67  | 3.10                  | 1.62  | 2.66  | 2.20  |
| Sesquioxide of iron | 1.20                 | 2.02  | 1.53  | 1.50  | 0.43                  | 0.95  | 16.66 | 2.30  |
| Phosphoric acid     | 67.73                | 66.86 | 73.31 | 70.92 | 34.53                 | 73.60 | 63.53 | 60.16 |
| Silica              | —                    | —     | 0.33  | 0.11  | —                     | —     | 6.52  | 0.62  |

**Amniotic and Allantotic Fluid.**—Regnauld(1) found in the amniotic fluid of women 1.2 per cent of solid matter, containing among other constituents urea, which can be detected when the fluid is evaporated to  $\frac{1}{3}$  at 100°, and then dried over sulphuric acid *in vacuo*. The residue is extracted with alcohol, and from the residue of the alcoholic solution the urea is extracted by boiling ether.

In the amniotic fluid of the hen, Stas(2) found acid urate of ammonia which, he says, is always present in the cloaca, and is

(1) Compt. Rend. XXXI, 218.

(2) Compt. Rend. XXXI, 629; Instit. 1850, 346.

secreted by the kidney. In the allantoic fluid he found neither urea or uric acid, but a nitrogenous organic substance, capable of crystallization, soluble in water and alcohol, also alkaline chlorides, sulphates, and phosphates.—In the allantoic fluid of the cow, he found all the salts which are contained in the urine of the cow, but no hippuric or benzoic acid; he found also fibrin, albumin, casein, and a considerable quantity of grape-sugar(1). The amniotic fluid of the cow contains, according to him, neither allantoin nor benzoic acid, but it contains all the salts of the urine, and a considerable quantity of albumin and fibrin; moreover, it is saturated with carbonic acid, and contains bicarbonate of potassa.—In the amniotic fluid of women, he also found urea; he also found this substance in the blood of the placenta, the fluid portion of which consists almost entirely of casein.

Amniotic  
and allan-  
toic fluid.

**Respiration of Muscles.**—G. Liebig(2) has made some experiments on the respiration of muscles, from whence it follows that a muscle (he used frogs' muscles) retains its property of contracting when acted on by the galvanic current longer in an atmosphere of oxygen, or of gas containing oxygen, than in one free from all oxygen; and that a muscle during the time that it retains the power of contraction gives out carbonic acid and absorbs oxygen.

**Digestion.**—We can only give the undermentioned references to the communications of Bence Jones(3) on digestion in general, of E. Lenz(4) on the digestion and absorption of fats, and of Lamert van Bueren(5) on the digestion of different kinds of milk.

**Pancreatic Fluid.**—Regarding the property which Bernard(6) states that the pancreatic fluid possesses of forming an emulsion with neutral fats, and causing them to separate rapidly into fatty acids and glycerin, Lassaigne(7) has found the pancreatic fluid of a dog exercises this action on oil, at a temperature from 12° to 15°, and that this occurs in an atmosphere of hydrogen, nitrogen, or carbonic oxide gas; the pancreatic fluid retains its alkaline reaction, and its property of acting upon oil for many days; sugar and gum undergo no change when in the same circumstances in which the oil is thus decomposed. Lassaigne(8) has made the observation that the feebly alkaline pancreatic fluid of the calf, on the

(1) Bernard (Compt. Rend. XXXI, 659) states that even at an earlier period, he found grape-sugar in the urine of the fetus of the cow and sheep, and in the amniotic and allantoic fluids.

(2) Müller's Archiv. 1850, 393; Berl. Acad. Ber. 1850, 339; Instit. 1851, 118.

(3) The Lancet, Jan. 19th, 1850; Froriep's Tagsberichten über d. Fortschr. d. Natur. u. Heilk. 1850, No. 163 u. 172.

(4) From the Inaugural Dissertation (Dorpat, 1850) abstracted in Schmidt's Jahrb. d. Med. LXVII, 146; see this Report, p. 382.

(5) From Nederl. Lanc. June, 1849, in Schmidt's Jahrb. d. Med. LXVIII, 3.

(6) Annual Report for 1849, III, p. 364.

(7) Compt. Rend. XXXI, 745; Instit. 1850, 378; J. Pharm. [3] XIX, 204; J. Pr. Chem. LII, 317.

(8) J. Pharm. [3] XIX, 203.

the contrary, forms no emulsion with oil at the temperature of  $15^{\circ}$ , nor even at  $38^{\circ}$ , and that it does not cause the liberation of any fatty acid.—E. Lenz(1) follows Frerichs(2) in opposing Bernard's view regarding the action of the pancreatic fluid in the digestion of fatty matter; he believes that it is neither necessary to the absorption of fat, nor that it very much promotes that process.

**Nutrition.**—Völcker(3) states that the determination of the value of any substance as nutriment from the amount of nitrogen it contains is erroneous; since, for example, the presence of salts of ammonia can lead to mistakes. He gives as an example *Agaricus prunellus*. The proportion of nitrogen in the whole mushroom was 0.74 per cent when fresh (6.61 when dried at  $100^{\circ}$ ) but only 0.54 (dried 4.80) per cent of the nitrogen was present in the plant in the form of protein-compounds; the residue was in the form of ammoniacal-salts, which remained in the sap even after all the protein-substances were precipitated by basic acetate of lead.

**Action of Analogous Substances on the Human Body.**—Schlossberger has observed(4) that wood-spirit, and the hydrated oxide of amyl, have the same physiological action on the animal organism as alcohol; they produce intoxication or sleep resembling syncope; they are rapidly decomposed in the blood (it was not determined whether they are changed into the corresponding acids), and they act on the mucous membranes just like alcohol.—Concentrated valeric and butyric acids, introduced into the stomach, act like acetic and formic acids.

**Blood.**—J. Weiss(5), in respect to the method proposed by him(6) of determining the quantity of blood contained in an animal from the quantity of iron contained in the ash of the animal, has found that it is based on an error, inasmuch as the blood is by no means the sole substance in the body which contains iron. Weiss could not obtain the fibrin of the blood, or the muscular substance of the body, free from iron. He also found iron in the ash of the bile, but not in the ash of the urine.

Verdeil and Dollfus(7) adopt the following method for determining the constituents of the blood; they have used it chiefly for the blood of the ox. The fibrin is separated from the fresh-drawn blood by heating it; the blood thus freed from fibrin is then mixed with an equal volume of water and heated in a water-bath, to coagulate the albumin and the colouring matter. The fluid is filtered through a cloth, and evaporated in a water-bath to

(1) Loc. cit. p. 381.

(2) Annual Report for 1849, III, 364.

(3) Chem. Gaz. 1850, 337; Instit. 1850, 326.

(4) Ann. Ch. Pharm. LXXIII, 212.

(5) Wien. Acad. Ber. December, 1850, 492.

(6) Annual Report for 1849, III, 365.

(7) Compt. Rend. XXX, 657; Instit. 1850, 170; Arch. Ph. Nat. XIV, 222; Ann. Ch. Pharm. LXXIV, 214.

the thickness of a syrup. On the addition of alcohol, a precipitate is occasioned; this is allowed to subside for twenty-four hours, it is then separated from the fluid and washed with alcohol.—The precipitate consists of an albuminous substance, soluble in water (albumin which was not perfectly coagulated); it also contains chloride of sodium and phosphate of soda. If this precipitate be dissolved in water, and acetate of lead added, a voluminous precipitate forms; the fluid separated from this precipitate gives, with basic acetate of lead, a precipitate which contains oxide of lead, and a non-nitrogenous organic acid, analogous to the acid produced by oxidation of sugar.—The fluid which is separated by filtration after the precipitation by alcohol is subjected to distillation. After the alcohol is distilled off, very weak sulphuric acid is added to the concentrated cold fluid; this causes the separation of an insoluble substance on the surface of the fluid, which has a strong and disagreeable odour, and consists chiefly of oleic acid, and under the microscope is seen to consist of fat globules and indistinct crystalline masses; frequently dark red crystals are seen, they have the same form as Virchow's *hämatoïdin*. By means of carbonate of lime the excess of sulphuric acid is separated from the fluid, which has been freed from the above insoluble substance by filtration; it is then evaporated, and dried *in vacuo* over sulphuric acid; from the perfectly dry residue cold absolute alcohol extracts nothing but urea, the existence of which was established by analysis; warm alcohol, mixed with ether, extracts from the mass which was heated with cold alcohol, hippurate of lime(1), and also some salts of volatile acids.

Mialhe(2) considers that the soluble substance which remains after coagulation by heat, and which he has designated(3) as *albuminose*, and established as a constituent of the blood, are identical, and that the acid which is similar to the acids formed by the oxidation of sugar, is formed in consequence of the action of the alkali of the blood on the starchy principles of the food, which are first changed into sugar, as he had already previously pointed out(4).

Marchal(5) states that the quantity of fibrin contained in the blood is lessened by shaking.

According to Guillot and Leblanc(6), casein (in solution) is a normal constituent of the blood of men and animals. It exists in excess in pregnant animals, before delivery and whilst suckling. In disease it may be almost entirely absent.

Regarding the blood of the placenta, see p. 383.

(1) See Annual Report for 1849, III, 367.

(2) Compt. Rend. XXX, 745.

(3) Compt. Rend. XIII, 261.

(4) Compt. Rend. XVII, 707; XX, 954.

(5) Compt. Rend. XXX, 30; Instit. 1850, 18.

(6) Compt. Rend. XXXI, 520, 585; Instit. 1850, 321, 338; J. Pr. Chem. LI, 395.



Clément(1) found the composition of blood in healthy horses to be :

|                    | Venous blood. |               |              |       | Arterial blood. |               |              |       |
|--------------------|---------------|---------------|--------------|-------|-----------------|---------------|--------------|-------|
|                    | First horse.  | Second horse. | Third horse. | Mean. | First horse.    | Second horse. | Third horse. | Mean. |
| Water . . . . .    | 805.5         | 826.7         | 813.1        | 815.1 | 815.0           | 823.4         | 821.2        | 819.8 |
| Albumin and salts  | 76.2          | 35.8          | 81.7         | 81.2  | 74.7            | 82.7          | 76.7         | 78.0  |
| Fibrin . . . . .   | 6.4           | 4.7           | 3.8          | 5.0   | 6.7             | 5.4           | 3.8          | 5.3   |
| Blood globules . . | 111.9         | 82.8          | 101.4        | 98.7  | 103.6           | 88.5          | 98.5         | 96.9  |

He also found the composition of the venous blood of a broken-winded horse to be A, the arterial blood B. In another horse, the composition of the blood drawn previous to the division of the pneumogastric nerves is represented at C; after they were divided, at D.

|                    | A.    | B.    | C.    | D.    |
|--------------------|-------|-------|-------|-------|
| Water . . . . .    | 796.6 | 803.5 | 822.5 | 798.9 |
| Albumin and salts  | 71.7  | 75.9  | 86.2  | 90.1  |
| Fibrin . . . . .   | 7.2   | 6.7   | 7.2   | 7.8   |
| Blood globules . . | 121.5 | 113.9 | 84.1  | 103.2 |

**Alkalies in Blood.**—Enderlin(2) found in the ashes of the blood that the quantity of soda (and chloride of sodium) always considerably exceeded the quantity of potassa (and chloride of potassium) (3). He met with one exception, on which he dwells farther in the paper referred to below.

**Carbonates in Blood.**—Mulder(4) has communicated a paper on the carbonates of the blood, and he enters into an examination of the facts which may be considered as opposed to the existence of carbonates in the blood(5). That acids evolve no considerable quantity of carbonic acid from highly concentrated serum of the blood, is no proof of the absence of carbonates from that blood; for if carbonate of soda is added to such serum (from 1 to 4 grms. to 1000 cubic centimeters of blood), no carbonic acid is evolved when it is so treated. The conclusions are inadmissible which have been drawn from the comparison of the quantity of carbonic acid taken up by water and serum, and then evolved from the latter, on the addition of acid; for the fact has been overlooked that acetic acid retains much more of the absorbed carbonic acid than water does. (Acetic acid, spec. grav. 1.070 at 16°, absorbs 3.5 times its vol. of carbonic acid; of spec. grav. 1.064, 3.0 times; of spec. grav. 1.053, 1.3 times; of 1.028 spec. grav., 1.1 times. These numbers, as well as

(1) Compt. Rend. XXXI, 289.

(2) Ann. Ch. Pharm. LXXV, 150.

(3) See his analysis in Annual Report for 1847 and 1848, II, 159.

(4) Scheik. Onderzoek. V, 7. Stuk, 435.

(5) With reference to these facts, see Annual Report for 1847 and 1848, II, 159.

those that follow, hold for mean temperature). 100 vols. of fresh serum do not absorb 200 vols. of carbonic acid, but as the mean of many experiments, only 117, and on the addition of acetic acid, 46 vols. of carbonic acid gas are evolved. According to him, 100 vols. of serum can contain 73 vols. of carbonic acid in chemical combination. The quantity of carbonate of soda which may possibly be contained in the blood must be taken as much greater than has been given by Liebig, and, on an average, amounts to 0.3 per cent of the blood (supposing that all the carbonic acid, which Mulder considers in a state of chemical combination, exists in the blood combined with soda). Blood contains carbonic acid in a state of solution, as well as in a state of chemical combination. Mulder does not admit that the phosphate of soda in the blood plays any part in the absorption of carbonic acid. It must, first of all, be determined whether phosphate of soda does exist in the blood(1); and if even it be present, the same action may be attributed to other salts contained in the blood—for example, to the phosphate of lime. Mulder holds that it is most in accordance with the present state of our knowledge to consider that carbonic acid exists in combination in the blood, and herein he would include compounds of carbonic acid with albumin, globulin, &c., with potassa, soda, &c., with phosphate of lime, phosphate of soda, &c.

**Ashes of the Blood.**—R. Weber(2) repeated his analysis of the ash of the same ox-blood, the inorganic constituents of which he had previously(3) endeavoured to determine, according to the method formerly employed by H. Rose(4). This time he has proceeded according to the lately published process of the same chemist (combustion by means of finely divided platinum, see the Report on Analytical Chemistry, in this Annual Report). He has obtained totally different results, which are given under A. (The watery extract of the ash had an alkaline reaction, and when acidified by nitric acid, gave no trace of carbonic acid).—Roser(5) examined the ash of coagulated and well-washed blood (the blood was coagulated, and then stirred and washed with water, until it no longer gave any trace of chloride of sodium; it gave 0.43 to 1.38 per cent of brick-red ash, which contained no carbonic acid). Under B the result is given for coagulated blood, washed with cold water

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(1) The contradictions which have arisen in the views regarding the inorganic constituents of the blood, have been chiefly caused by the fact that hitherto the distinction between the blood of the flesh- or corn- and of the grass-eating animals, has not been duly attended to. The first contains only phosphates; the last, according to the kind of nourishment, contains varying quantities of carbonates. See Liebig's Chemical Letters.

(2) Pogg. Ann. LXXXI, 410.

(3) Annual Report for 1849, III, 367.

(4) Annual Report for 1847 and 1848, II, 237; Annual Report for 1849, III, 413.

(5) Ann. Ch. Pharm. LXXIII, 334.

Ashes of  
the blood.

only; under C, from blood afterwards extracted with alcohol and ether; under D, from blood treated with hot water. In the following table the results are stated, after subtraction of the carbon and sand. By comparison with the composition of the ash of the whole blood, it follows that water extracts from the coagulated blood chiefly chloride of sodium and alkaline phosphate.

|                               | A.     | B.      | C.    | D.     |
|-------------------------------|--------|---------|-------|--------|
| Silica . . . . .              | 1.11   | 1.80    | 1.89  | 2.01   |
| Sesquioxide of iron . . . . . | 7.03   | 54.72   | 51.06 | 52.81  |
| Phosphoric acid . . . . .     | 4.17   | 0.69    | 3.30  | 9.00   |
| Lime . . . . .                | 0.73   | 11.02   | 12.89 | 9.63   |
| Magnesia . . . . .            | 0.24   | 5.19    | 4.71  | 2.52   |
| Soda . . . . .                | 31.90  | 17.03 { | 13.60 | 16.61  |
| Potassa . . . . .             | 7.00   |         | 2.01  | 0.84   |
| Sulphuric acid . . . . .      | 1.16   | 8.60    | 9.63  | 6.58   |
| Chlorine . . . . .            | —      | 0.92    | 0.88  | —      |
| Chloride of sodium . . . . .  | 46.66  | —       | —     | —      |
|                               | 100.00 | 99.97   | 99.97 | 100.00 |

R. Weber(1) has also examined the inorganic constituents of the serum and clot of the blood of the horse, and he has done this in two ways: firstly, according to H. Rose's former method(2), extracting the carbonized substance with water, and then with hydrochloric acid, determining the dissolved matters, and then reducing the residue to an ash, and analyzing it; secondly, in the following way, the unburnt substance is first exhausted with water, and then with hydrochloric acid, after which the residue is incinerated and reduced to ash. The serum (slightly red and clear, of spec. grav. 1.029 at 15°.6) gave, when evaporated and dried at 100°, 9.09 per cent of residuc. 121.56 grms. of this dry serum gave (when incinerated), by the first method, an extract to water, which left 9.513 grms. ash, of the percentage composition A; the residue gave to dilute hydrochloric acid 0.318 grm., having the composition B; after being reduced to ash, there remained 0.457 grm., having the composition C; hence, by calculation, the whole ash (0.75 per cent of the fresh serum, 8.34 per cent of the serum when dried at 100°) is given under D. 121.56 grms. of the dried serum gave, by the second method, with hot water a fluid, the solid constituents of which were reduced to dryness, and burnt. Water extracted from the charcoal thus obtained 9.600 grms. of fixed constituents, and then hydrochloric acid 0.067 grm. (taking up all that remained). The percentage composition of both together is given at A; the residue gave, with dilute hydrochloric acid, 1.324 grms. of fixed constituents, having the composition B; when reduced to ash, there remained 0.173 grm. of the composition C;

(1) Pogg. Ann. LXXXI, 99.

(2) Annual Report för 1847 and 1848, II, 237; Annual Report for 1849, III, 413.

the composition of the whole ash (0.80 per cent of the fresh serum, 8.87 per cent of the serum dried at 100°), calculated from this, is given at D. Ashes of the blood.

|                      | According to the first method. |       |       |       | According to the second method. |       |       |       |
|----------------------|--------------------------------|-------|-------|-------|---------------------------------|-------|-------|-------|
|                      | A.                             | B.    | C.    | D.    | A.                              | B.    | C.    | D.    |
| Chloride of sodium   | 70.52                          | —     | —     | 65.21 | 81.32                           | —     | —     | 72.88 |
| Potassa . . . . .    | 2.34                           | 11.95 | 5.91  | 2.80  | 2.64                            | 3.90  | 14.45 | 2.95  |
| Soda . . . . .       | 14.00                          | 38.67 | 25.38 | 15.27 | 7.87                            | 58.84 | 43.35 | 12.93 |
| Lime . . . . .       | —                              | 22.96 | 30.42 | 2.06  | 0.14                            | 23.47 | 5.20  | 2.28  |
| Magnesia . . . . .   | —                              | 1.26  | 4.81  | 0.25  | 0.03                            | 2.74  | —     | 0.27  |
| Sesquioxide of iron  | —                              | 2.52  | 3.29  | 0.22  | 0.03                            | 1.26  | 7.52  | 0.26  |
| Phosphoric acid . .  | 0.27                           | 22.64 | 7.13  | 2.15  | 0.65                            | 9.79  | 17.92 | 1.73  |
| Sulphuric acid . . . | 2.02                           | —     | —     | 1.86  | 2.34                            | —     | —     | 2.10  |
| Carbonic acid . . .  | 9.40                           | —     | —     | 8.69  | 4.90                            | —     | —     | 4.40  |
| Silica . . . . .     | 0.13                           | —     | 3.06  | 0.26  | —                               | —     | 11.56 | 0.20  |

The clot was only freed from serum by allowing it to run off and be absorbed by blotting-paper; 283.9 grms. of the clot dried at 100° gave (when burnt) by the first method an extract to water weighing 4.373 grms. of the percentage composition A. Then to hydrochloric acid 0.466 grm. of the composition B. The residue gave 2.498 grms. of ash of the composition C, whence the composition of the whole ash (2.58 per cent of the dried clot) is reckoned and given under D. —288.12 grms. of the clot dried at 100° gave by the second method to hot water, 5.486 grms. of fixed constituents (out of the carbonized mass of the aqueous extract 5.406 grms. could be dissolved by water, 0.080 by hydrochloric acid) having the percentage composition A; after this hydrochloric acid dissolved 1.249 grms. of the composition B. The residue reduced to ash gave 0.985 grm. of the composition C; whence the composition of the whole ash (2.68 per cent of the dried clot) is calculated and given under D.

|                       | According to the first method. |       |       |       | According to the second method. |       |       |       |
|-----------------------|--------------------------------|-------|-------|-------|---------------------------------|-------|-------|-------|
|                       | A.                             | B.    | C.    | D.    | A.                              | B.    | C.    | D.    |
| Chloride of potassium | 10.40                          | —     | —     | 6.22  | 41.40                           | —     | —     | 29.87 |
| Chloride of sodium .  | 27.49                          | —     | —     | 16.43 | 24.06                           | —     | —     | 17.36 |
| Potassa . . . . .     | 41.73                          | 37.55 | 33.07 | 38.64 | 21.03                           | 38.59 | 6.50  | 22.36 |
| Soda . . . . .        | —                              | 25.32 | 7.60  | 4.21  | —                               | 18.17 | 4.36  | 3.55  |
| Lime . . . . .        | —                              | 6.87  | 6.00  | 2.49  | 0.33                            | 13.21 | 1.32  | 2.58  |
| Magnesia . . . . .    | —                              | 3.21  | 0.92  | 0.52  | 0.15                            | 2.16  | 0.51  | 0.53  |
| Sesquioxide of iron . | —                              | 8.38  | 30.03 | 10.79 | 0.28                            | 6.16  | 71.17 | 10.43 |
| Phosphoric acid . . . | 7.22                           | 17.60 | 51.38 | 12.74 | 7.49                            | 19.87 | 15.23 | 10.64 |
| Sulphuric acid . . .  | 0.05                           | —     | —     | 0.03  | 0.13                            | —     | —     | 0.09  |
| Carbonic acid . . .   | 12.58                          | —     | —     | 7.52  | 3.00                            | —     | —     | 2.17  |
| Silica . . . . .      | —                              | 1.07  | 1.00  | 0.41  | —                               | 1.84  | 0.91  | 0.42  |

**Liver.**—Bernard(1), found in continuation

Liver.

**covery of the presence of sugar in the liver**(1), that this organ, in all kinds of animals in the normal state, contains sugar, and that this production of sugar is independent of the nature of the food. He also found that after the division of the pneumo-gastric nerves in the neighbourhood of the heart this formation of sugar ceased.

**Spleen.**—Scherer(2) has found in the spleen a substance closely related to xanthic oxide. The spleen of the ox is boiled with water, and the fluid precipitated by baryta-water. By evaporation of the filtrate the excess of baryta separates as carbonate, and at the same time two organic substances, (these separate in greater quantity mixed with sulphate of baryta on the addition of sulphuric acid), which are soluble in boiling dilute alkali and precipitable from the solution by hydrochloric or carbonic acid. The precipitate which forms on the addition of these acids consists of uric acid, but the greater portion is a new substance which when heated with nitric acid becomes yellow. To separate it from uric acid it is dissolved in potassa, chloride of ammonium added and the fluid separated from the urate of ammonia evaporated, when the new substance is deposited as a yellow-white crystalline powder. This process is repeated, and the substance then dissolved in dilute caustic potassa and precipitated by carbonic acid. The crystalline white powder so obtained differs from xanthic oxide in that after being dried it remains a crystalline powder which can be easily powdered, without assuming a waxy lustre, and dissolves in nitric acid with evolution of gas (from the hot solution white crystals separate on cooling). It is almost entirely insoluble in cold hydrochloric acid, but slightly soluble in boiling acid. It dissolves in 1090 parts of cold and 180 parts of boiling water. The solution in water has no reaction on vegetable colours. The substance dried at 100° or 120° gave the composition  $C_5H_2N_2O$ . Thus it contains one atom less oxygen than the xanthic oxide. Scherer proposes for this substance the name of *hypoxanthin*. He also found this substance in the human spleen (also in muscular structure of the heart). In the spleen creatin does not appear to be present.

**Flesh.**—D. Price(3) found that the flesh of the whale (of *Balenoptera musculus*) when treated according to Liebig's method(4) gives creatin, although only in small quantity.

**Ashes of Flesh.**—R. Weber made previously(5) an analysis of the ash of the flesh of the horse according to H. Rose's old method(6),

(1) Annual Report for 1847 and 1848, II, 175.

(2) Ann. Ch. Pharm. LXXIII, 328; Chem. Gaz. 1850, 181; J. Pharm. [3] XVIII, 73.

(3) Chem. Soc. Qu. J. III, 229.

(4) Annual Report for 1847 and 1848, II, 162.

(5) Annual Report for 1849, III, 369.

(6) Annual Report for 1847 and 1848, II, 237; Annual Report for 1849, III, 413.

the flesh was burnt before it was extracted with water and hydrochloric acid, and ultimately the residual coal was reduced to ash. He has now(1) communicated an analysis made in a similar way, but in which the flesh before being burnt was extracted with water and hydrochloric acid. 5 lbs, 8 loth (Prussian) of flesh from the fore-leg of a lean horse (freed from blood by the injection of water into the brachial artery) lost at 100° 79·55 per cent in weight. Extracted with water it gave a liquid in which there were 16·122 grms. of ash having the percentage composition A; the hydrochloric extract gave 3·495 grms. of ash of the composition B; the residue which then remained was burnt, and the carbonized mass gave to water 0·028 grm., and then to dilute hydrochloric acid 0·322 grm.; the two together had the composition C, and a residue was left, which when burnt gave 0·814 grm. of ash of the composition D. The composition of the whole ash of the horse-flesh (0·85 per cent of fresh flesh; 4·14 per cent of flesh dried at 100°; 77·63 per cent of the whole ash was soluble in water; 18·45 in dilute hydrochloric acid, and 3·92 remained in the residue) is hence calculated and given under E.

Ashes of  
flesh.

|                               | A.    | B.    | C.    | D.    | E.    |
|-------------------------------|-------|-------|-------|-------|-------|
| Chloride of sodium . . . . .  | 9·37  | —     | —     | —     | 7·21  |
| Potassa . . . . .             | 38·01 | 26·81 | 9·64  | 9·10  | 34·45 |
| Soda . . . . .                | 6·37  | 5·66  | 4·22  | 3·41  | 6·08  |
| Lime . . . . .                | 0·99  | 4·35  | 24·70 | 11·05 | 2·33  |
| Magnesia . . . . .            | 1·56  | 12·37 | 1·20  | 3·93  | 3·16  |
| Sesquioxide of iron . . . . . | 0·67  | 1·00  | 6·62  | 6·14  | 0·98  |
| Phosphoric acid . . . . .     | 43·12 | 49·82 | 53·62 | 66·31 | 45·21 |

Staffel(2) has examined the ash of veal and of beef. The first was taken from the breast, free from skin and fat, and contained 77·64 per cent water. The dried flesh contained 3·1 per cent ash. The incinerated flesh was extracted with water and the extract analyzed, the residue was partially reduced to ash and extracted with water and hydrochloric acid, and this was afterwards repeated. From the separate results the total result was calculated. The beef contained 72·63 per cent of water; the dried flesh contained 2·2 per cent of ash; the carbonized mass was also first extracted with water, and the residue (excepting a portion, the ash of which served for the determination of the lime) was mixed with acetate of lime and then reduced to ashes. We give only the results of the whole analyses:

|                                 | Ash of veal. | Ash of beef. |
|---------------------------------|--------------|--------------|
| Chloride of sodium . . . . .    | 10·59        | 7·49         |
| Chloride of potassium . . . . . | —            | 4·01         |
| Soda . . . . .                  | 2·85         | 34·91        |
| Potassa . . . . .               | 34·40        | 2·61         |
| Magnesia . . . . .              | 1·45         | 2·35         |
| Lime . . . . .                  | 1·99         | 5·09         |

(1) Pogg. Ann. LXXXI, 92.

(2) Arch. Pharm. [2] LXIV, 148.

|                               | Ash of veal. | Ash of beef. |
|-------------------------------|--------------|--------------|
| Alumina . . . . .             | trace        | trace        |
| Sesquioxide of iron . . . . . | 0.27         | 0.96         |
| Phosphoric acid . . . . .     | 48.13        | 39.28        |
| Sulphuric acid . . . . .      | —            | 1.77         |
| Silica . . . . .              | 0.81         | 1.52         |

**Bile.**—As respects many communications of Enderlin on human bile(1), on bilin(2), on a peculiar decomposition of ox-bile(3), on the presence of the bile in the blood(4), we must refer to the sources mentioned below.

**Cholesterin.**—Heintz(5) has communicated investigations on the presence of water in crystallized cholesterin and on the products of distillation of that substance; he gives the following as his results. The cholesterin crystallized from a solution of alcohol or from the ethereal solution mixed with alcohol, has the composition  $C_{28}H_{52}O + HO$ , and there is no ground for the formula  $C_{84}H_{72}O_3$  given by Schwendler and Meissner(6) for cholesterin free from water, or for  $C_{81}H_{69}O_3$  given by Zwenger(7). The form of the crystallized cholesterin is monoclinometric, observed planes are  $(\infty P \infty)$ ,  $0 P$ ,  $+P \infty$ ,  $\infty P$ ,  $\infty P \infty$ ;  $0 P : \infty P \infty = 100^\circ 30'$ ;  $+P \infty : 0 P = 127^\circ 50'$ ;  $+P \infty : \infty P \infty = 131^\circ 34'$ ;  $\infty P : (\infty P \infty) = 110^\circ 14'$ ;  $\infty P : \infty P = 139^\circ 45'$ . Cholesterin can be distilled very slowly without undergoing change at the temperature of boiling mercury not only *in vacuo*, as Chevreul long since found, but even when exposed to the air. When the cholesterin is distilled at a higher temperature some impure cholesterin first passes over, then follows a mixture of a little cholesterin and also a very little of  $\alpha$  cholesterone(8), with the ultimate products of distillation. Lastly, a clear, semi-fluid oil comes over, from which, by fractional distillation, a thin fluid substance can be separated, consisting of equal atoms of carbon and hydrogen. The greater part of the oil, however, consists of a semi-fluid substance which rapidly absorbs oxygen, and has probably the composition represented by the formula  $C_{28}H_{22}$ . By distillation, the residue in the retort becomes constantly richer in carbon and poorer in hydrogen; it ceases to contain cholesterin; when the greater part of the substance has distilled over, there remains a brown substance very slightly soluble in ether, and very rich in carbon, and containing only 4.5 per cent of hydrogen. It probably consists of  $C_3H$ . If the vapour of cholesterin is passed through tubes at a low red heat, carbon is deposited in them, and a thick, fluid, blackish-brown substance

(1) Ann. Ch. Pharm. LXXV, 162.

(2) Ibid. 166.

(3) Ibid. 154.

(4) Ibid. 167.

(5) Pogg. Ann. LXXIX, 524; Ann. Ch. Pharm. LXXVI, 366.

(6) Ann. Ch. Pharm. LIX, 107; Berzelius' Jahresber. XXVII, 623.

(7) Annual Report for 1847 and 1848, II, 194.

(8) Annual Report for 1849, III, 380.

distils over, and a gas is given off which consists of marsh-gas and olefiant-gas. Semen.

**Semen.**—Frerichs(1) has examined semen. When pure it is neutral (once only he found that it had a feebly alkaline reaction). The full-grown spermatozoa, according to him, consist of binoxide of protein, the same substance which, according to Mulder, forms the chief constituent of the epithelium and of the horny textures in general. The spermatozoa contain about 4 per cent of a butter-like fat, also phosphorus in an unoxdized state, and about 5 per cent of phosphate of lime. The fluid portion of the semen consists of a dilute solution of mucus which also contains chloride of sodium and a small quantity of alkaline phosphate and sulphate. The imperfectly-developed spermatozoa consist of an albuminous substance which diminishes in quantity as the development proceeds. The fully-developed semen contains no albuminous compound. The semen of fish, birds, and all mammalia has, on the whole, the same chemical composition.

**Ash of Milk.**—R. Weber(2) examined the ash of the same carbonized milk of the cow, the inorganic constituents of which he had already(3) previously endeavoured to determine according to the method formerly employed by H. Rose(4). This time he followed H. Rose's recent method, that is combustion by means of finely-divided platinum (see the Report of Analytical Chemistry for this year). He found in 100 parts of ash (the watery solution of which had an alkaline reaction but contained no carbonic acid):

|                       |       |               |       |                 |       |
|-----------------------|-------|---------------|-------|-----------------|-------|
| Chloride of potassium | 9.49  | Lime          | 17.31 | Phosphoric acid | 29.13 |
| Chloride of sodium    | 16.23 | Magnesia      | 1.90  | Sulphuric acid  | 1.15  |
| Potassa               | 23.77 | Oxide of iron | 0.33  | Silica          | 0.09  |

99.40

**Urine.**—Regarding the investigations of Böcker(5) on the alteration of the urine and blood in gout, we must refer to the treatise itself. So also regarding Bence Jones'(6) examination of the so-called chylous urine (in which, in addition to suspended fat, albumin, fibrin and blood globules were found).

**Ammonia in Urine.**—Boussingault(7) has determined the quantity of ammonia and the total quantity of nitrogen in the urine of different men and animals; he has obtained the following results (regarding the method he followed, see the Report on Analytical Chemistry):

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- (1) Todd's Cyclopædia of Anatomy and Physiology, article Semen.
  - (2) Pogg. Ann. LXXXI, 412.
  - (3) Annual Report for 1849, III, 382.
  - (4) Annual Report for 1847 and 1848, II, 237; Annual Report for 1849, III, 413.
  - (5) From Rh. Monatsschrift, February, 1850, in Schmidt's Jahrb. d. Med. LXVI, 275 (in abstr.)
  - (6) Proceedings of the Royal Society, No. 75, 930; Phil. Mag. [3] XXXVII, 302; Chem. Gaz. 1850, 278; Instit. 1850, 406.
  - (7) Ann. Ch. Phys. [3] XXIX, 472; J. Pr. Chem. LI, 281.



Ammonia  
in urine.

|                                   | In 1000 parts were: |          | Remarks. |
|-----------------------------------|---------------------|----------|----------|
|                                   | Nitrogen.           | Ammonia. |          |
| Child, 8 months                   | 3.20                | 0.34     | *        |
| Child, 8 years                    | 6.94                | 0.28     | *        |
| Man, 20 years                     | 16.04               | 1.14     | *        |
| Man, 46 years                     | 18.40               | 1.40     | *        |
| The same                          | 15.70               | 1.27     | †        |
| Man, 46 years                     | 12.20               | 0.74     | ‡        |
| Woman with diabetes               | 10.20               | 1.35     | *        |
| Man, 35 years, with gravel        | 5.85                | 0.42     | *        |
| Man, 17 years, with scarlet-fever | 19.44               | 1.66     | *        |
| Cow                               | 13.30               | 0.06     | *        |
| Another cow                       | 18.10               | 0.10     | *        |
| Another cow                       | 25.14               | 0.09     | *        |
| Horse                             | 16.25               | 0.00     |          |
| Another horse                     | 12.04               | 0.04     |          |
| Another horse                     | 17.31               | trace    |          |
| Camel                             | 28.84               | 0.04     | *        |
| Elephant                          | 3.06                | 1.12     | §        |
| Rhinoceros                        | 5.11                | 0.80     | *        |
| Rabbit                            | 6.89                | 0.15     |          |
| Another rabbit                    | 5.00                | 0.00     |          |
| Another rabbit                    | 7.94                | 0.03     |          |
| Snake ( <i>python</i> )           | 162.44              | 8.57     |          |

\* Morning, before breakfast

† On the same day, one hour after breakfast

‡ After breakfast

§ Passed during the night, and perhaps partly decomposed

|| For the composition of this snake's urine, see p. 395

**Volatile Acids of Urine.**—Stadele (1) has examined the volatile acid of the urine.—Fresh cows' urine (about 80 lbs) was mixed with hydrate of lime, after being boiled the fluid was poured off from excess of lime, evaporated to one-eighth at a boiling temperature, the filtrate well cooled, mixed with hydrochloric acid until it was strongly acid, the hippuric acid which was deposited was separated from the mother-liquor after twelve hours (see p. 278). When the mother-liquor was distilled, a disagreeable-smelling, milky fluid came over, from which yellow, or greenish, tenacious oil-drops separated. By repeated rectification the volatile bodies dissolved in water were condensed and an oily, slightly yellow fluid obtained, which sunk in the water which distilled over with it. This fluid is a mixture of several substances. It was mixed with a weighed quantity of hydrate of potassa until it had a strongly alkaline reaction and then distilled, when a feebly-yellow, light oil was obtained, with penetrating smell (resembling that of a mixture of oil of rosemary and origanum); this oil (which appears to be formed out of the former oil by the action of potassa) contains nitrogen. It is soluble in concentrated sulphuric acid with a deep wine-red colour, and when dissolved in water gives no preci-

(1) Ann Ch Pharm LXXVII, 17, J Pr Chem. LII, 39 (in abstr), Chem. Gaz. 1851, 149, Institut 1851, 86.

pitate with basic acetate of lead, and no colour with sesquichloride of iron. In order to remove the hydrochloric and benzoic acids which are in combination with the potassa (from the separation and decomposition of the hippuric acid)  $\frac{2}{3}$  of the potassa which was used was neutralized with sulphuric acid, and then the whole was distilled as long as basic acetate of lead gave a precipitate. The distillate, which smelt of phenol (phenylic acid, carbolic acid) was repeatedly distilled with common salt until the greater part of the acids were obtained in an oily form, and very little water remained behind. As this had a strong acid reaction, it could not consist only of phenol. In order to separate the body which had an acid reaction, the distillate was saturated with carbonate of soda, and for twelve hours frequently shaken with it.—That portion of the distillate which did not combine with carbonate of soda was extracted with ether, the ether was distilled off, and the residue was distilled with concentrated solution of caustic potassa in order to remove the ether entirely as well as some of the above-mentioned neutral oil. The residual potassa-compound was decomposed by bicarbonate of potassa, and the substance which came over was left in contact with chloride of calcium and rectified from it. Thus a distillate was obtained from which water and phenol passed over from 120° to 180° (the phenol was recognized by its characteristic reaction, and also by giving rise to picric and phenylsulphuric acids). At a higher temperature—namely, at 195°—in addition to phenol a fluid resembling that substance which has a boiling-point of 195°, and forms with sulphuric acid a compound which separates immediately in fine white leaves, and, as is probable, from Städeler's researches, has the composition  $C_{14}H_8O_2$ , which would make it isomeric with anisol(1); Städeler calls this compound *taurylic acid*(2).—The portion of the distillate which was combined with soda had the ether which was dissolved separated by evaporation; it was decomposed by sulphuric acid and then distilled. The distillate (which had a smell resembling that of butyric acid) separated into two layers, an under oily and an upper acid and watery, (solution of the under). This distillate was saturated with carbonate of baryta and crystallized fractionally. The proportion of baryta in the different salts which crystallized one after the other, rose from 27.6 to 44.5 per cent. In the largest quantity a baryta-salt was obtained, which was not fusible, and contained somewhat more than 39 per cent of baryta, and, according to Städeler, had the composition  $BaO, C_{14}H_{11}O_3$  (a silver-salt prepared from this had the compo-

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(1) Annual Report for 1849, III, 277.

(2) Städeler remarks that the formula given to taurylic acid is also that which, according to Ettling's analyses, has been assumed for creosote; but that his analyses, when calculated according to the later atomic weights, agree better with the formula  $C_{12}H_7O_2$ . He recalls to mind that the creosote which is now sold is nothing but phenol; he found some which was remarkable for its smoky smell, and consisted only of impure phenol.

Volatile  
acids of  
urine.

sition  $\text{AgO}$ ,  $\text{C}_{14}\text{H}_{11}\text{O}_3$ ); the acid of this salt, which Städelér calls *damaluric acid* ( $\delta\alpha\mu\alpha\lambda\upsilon\varsigma$ , calf;  $\sigma\upsilon\rho\omicron\nu$ , urine), smells like valeric acid), is somewhat heavier than water, gives with basic acetate of lead a white precipitate consisting of prismatic microscopical crystals; contains two atoms hydrogen less than cenanthic acid, and hence stands to this in the same relation as angelic acid does to valeric acid. The baryta-salt which is obtained in the next greatest quantity, is that which first separates (fusible), it contains between 27 and 28 per cent of baryta; for this acid, Städelér proposes the name of *damolic acid*.

In order to determine whether these acids were contained ready-formed in the urine, Städelér evaporated urine, at a low heat, to  $\frac{1}{2}$  of its volume, then added dilute sulphuric acid, and after twelve hours separated the hippuric acid which had been deposited. Ether extracted from the matter a red-brown oily fluid, which was then heated with a solution of carbonate of soda. The portion not combined with carbonate of soda was extracted with ether, the ethereal solution evaporated, and the residue distilled with a little water; the yellow drops which passed over gave the reaction of phenol. The part combined with soda was set free by sulphuric acid, and then also extracted with ether. The residue of the ethereal solution gave, when distilled with water, oily drops, having the smell of damaluric and damolic acids.—By simple distillation of cows' urine a distillate was obtained, in which neither phenol nor damaluric acid could be recognized.—Städelér accordingly assumes that the above-mentioned substances are ready-formed in the urine, and exist therein combined with an alkali; he considers it, however, as doubtful whether the damaluric acid is not also partly formed by the action of potassa on another substance present in the urine.

The volatile acids of the urine of the horse are the same as those of the cow's urine, according to Städelér; the same acids, as well as the aromatic smelling oil, are also present in human urine.

Städelér conjectures that phenol is formed in the body from members of the salicyl-group, which are present in the food, and that they probably, also, arise from some constituents of the body, as the gelatious tissues(1). He recalls to mind that Wöhler has discovered phenol and salicin in castoreum(2), and is of opinion that these substances were brought to the castoreum (the cuticular unguent of the prepuce of the beaver) by the urine.

**Changes of Different Substances by Passing through the Body into the Urine.**—It is well known that when benzoic acid  $\text{C}_{14}\text{H}_6\text{O}_4$  is taken internally it is changed into hippuric acid  $\text{C}_{18}\text{H}_9\text{NO}_6$ , which passes out

(1) Schlieper (Ann. Ch. Pharm. LIX, 22; Berzelius' Jahresber. XXVII, 652) found a trace of phenol among the products of the oxydation of gelatin.

(2) Annual Report for 1847 and 1848, II, 175.

as such in the urine. Bertagnini(1) has found that in a precisely similar way the nitrobenzoic acid  $C_{14}H_5(NO_4)O_4$  passes into nitrohippuric acid  $C_{18}H_8N_2O_{10} = C_{18}H_8(NO_4)NO_6$ ; the latter acid can also be obtained from hippuric acid by treating it with a mixture of fuming nitric acid and sulphuric acid, and by the action of hydrochloric acid, analogous to hippuric acid, it separates into nitrobenzoic acid and glycocine. Bertagnini's more accurate statements(2) regarding nitrohippuric acid come under the year 1851, and must be mentioned in next year's Report.—A. W. Hofmann(3) found that cuminic acid  $C_{20}H_{12}O_4$ , which is the homologue of benzoic acid, when taken internally passed off in the urine unchanged; after tolulic acid  $C_{16}H_8O_4$  was taken, which was also innocuous, no tolulic acid could be found in the urine, but a small quantity of a crystallizable substance, which was indifferent and soluble in ether, and was not in sufficient quantity to admit of farther investigation.

Bence Jones(4) found that the reaction of tartrate of ammonia and tartrate of potassa(5) on the urine were totally different, and that even strong doses of carbonate of ammonia did not lessen the acid reaction of the urine. Ammoniacal salts, and also urea, are partially changed in the body into nitric acid, which can be detected in the urine after distillation. The urine passed three hours after from 30 to 40 grains of chloride of ammonium were taken contained a detectable quantity of nitric acid.

**Serpents' Urine.**—In the fresh urine of a snake (of a python), which had the consistence of dough, Boussingault(6) found 46·3 per cent uric acid; 0·9 ammonia; 5·6 phosphates, lime, magnesia, potassa; 0·2 yellow fat; 1·0 albuminous substance; 46·0 water and loss.

**Fæces.**—J. Percy(7) has examined the composition of the fæces in health and in *diabetes mellitus*. We only mention here that he found for the first (dried at  $100^\circ$ ), in one case, 46·2 per cent carbon, 6·7 hydrogen, 16·4 ash; in another case, 49·8 per cent carbon, 7·1 hydrogen, 14·5 ash. The examination of the composition of the fæces in *diabetes mellitus* led to no general results, and regarding it, and also regarding D. Campbell's(8) remarks, we must refer to the original communication.—Güterbock(9) has given the quantity of salt in the evacuations in cholera; we may refer to what was said in the Report of last year, p. 559.

Changes of  
different  
substances  
by passing  
through  
the body  
into the  
urine.

(1) Compt. Rend. XXXI, 490; Instit. 1850, 313; J. Pharm. [3] XVIII, 351; J. Pr. Chem. LI, 255.

(2) Ann. Ch. Pharm. LXVIII, 100.

(3) Ann. Ch. Pharm. LXXIV, 342; Chem. Soc. Qu. J. III, 181; J. Pharm. [3] XVII, 318.

(4) Compt. Rend. XXXI, 898; Instit. 1851, 13; Ann. Ch. Pharm. LXXVIII, 251.

(5) See the Annual Report for 1849, III, 382.

(6) Loc. cit. p. 392.

(7) Chem. Gaz. 1850, 102, 122.

(8) Chem. Gaz. 1850, 155.

(9) Pogg. Ann. LXXIX, 323.

Fæces.

In cow-dung (not dried) Boussingault(1) found 0·021 per cent ammonia; in horse-dung 0·027 per cent ammonia, 0·32 nitrogen, 76 water.

**Intestinal Calculus. Urinary Concretions.**—Lenoble(2) has examined a concretion from the stomach of a cow; he gives as constituents carbonate of lime, yellow colouring matter (insipissated bile), animal mucus, and a fat resembling cholesterin.—G. Reich(3) found a concretion from the urethra of a goat consisted of 48·43 per cent carbonate of lime, 32·64 phosphate of lime, 14·43 phosphate of magnesia and ammonia, 4·50 animal matter.

**Fluid from Ovarian Dropsy.**—In 1000 parts of the fluid from an ovarian tumour Th. J. Herapath(4) found 0·90 fibrin; 19·84 albumin; 0·51 fat and lactic acid, of alkaline lactate; 4·20 urea, with a trace of uric acid; 0·18 extractive matter soluble in alcohol, insoluble in ether; 0·44 gelatin, with mucus and extractive matter; 0·29 albumin with soda; 965·41 water and loss; and in the ash: 0·98 carbonate of soda, 0·01 sulphate of potassa, 0·59 phosphate of potassa, 6·20 chloride of sodium, 0·07 carbonate of lime, 0·05 carbonate of magnesia, 0·33 phosphate of lime, traces of phosphate of iron and alumina, sulphate of lime and silica.

**Secretion of Wax.**—Dujardin(5) has made a communication regarding the secretion of wax by many insects.

**Secretion of Salicylic Acid.**—The well-known strong smell of the larvæ of *Chrysomela populi*, which live on willows and poplars, arises from salicylic acid (hydride of salicyl, the chief constituent of the oil of *Spiræa ulmaria*), which is evidently formed from salicin in the vital processes of these animals. Along the body these larvæ have little swellings, from which when the larvæ are pressed drops of oil escape, which possess the peculiar smell. If the animal is placed in a very dilute solution of sesquioxide of iron, and then pressed with a forceps, the characteristic violet-colour becomes evident. By distilling the larvæ with water the salicylic acid can be obtained in larger quantity. The watery distillate, when mixed with alcohol, and then with acetate of copper and a little caustic potassa gives a green precipitate which in twenty-four hours changes into the salicylite of copper; discovered by Ettling; this reaction removes every doubt regarding the nature of this oily acid, showing especially that it is not gaultheric acid.

(1) Loc. cit. p. 392.

(2) J. Pharm. [3] XVII, 199.

(3) Arch. Pharm. [2] LXII, 34.

(4) Chem. Gaz. 1850, 88.

(5) Compt. Rend. XXX, 172.

# ANALYTICAL CHEMISTRY.

**Analysis of Gases.**—Doyère(1) has described, as the first part of his investigations upon the respiratory process, his methods of proceeding in the analysis of gases. We can here furnish only the general principles of these methods, and must refer for the details to the original treatise. The chemical change, or separation, of the individual gases contained in a mixture, is effected by Doyère in vessels distinct from those employed for measuring; for the latter purpose, graduated tubes are used, and for the former, an apparatus constructed after the manner of Ettling's gas-pipette(2). The measuring-tube is placed in a trough filled with water, and its lower extremity only dips into mercury; the effect of variations in atmospheric pressure or temperature during a connected series of measurements, is obviated by the use of a glass bell-jar, which dips into the water of the trough, and encloses a constant quantity of atmospheric air, which is always reduced to the same volume before each measurement by altering the height of the column of water pressing upon it, when a corresponding correction necessarily falls upon the gas in the measuring-tube. In general, Doyère prefers the analysis by absorption to all other methods; in order, however, to ensure accurate results, the absorbing agents must be (previously) saturated with the gas which remains after their action upon the mixture; they should, moreover, be capable of absorbing the gas (with agitation) in a very short time, and lastly, of absorbing a volume of gas much larger than their own. Doyère recommends the repeated action of the absorbents upon the gas to be analyzed. For the absorption of oxygen, he employs an ammoniacal solution of subchloride of copper; for that of carbonic acid, potassa; for that of sulphuretted hydrogen, sulphate of copper (acetate of lead absorbs carbonic acid also). His results with regard to the analysis by detonation with explosive gas were communicated in an abstract which appeared in the Annual Report for 1849, III, p. 392.

Analysis of  
gases.

R. F. Marchand(3) also has described his process for the analysis

(1) Ann. Ch. Phys. [3] XXVIII, 5.

(2) Ann. Ch. Pharm. LIII, 141; Berzelius' Jahresber. XXVI, 288.

(3) J. Pr. Chem. XLIX, 449.

of gases; it is essentially founded upon the methods of Bunsen(1) and of Regnault and Reiset(2).

Liebig(3) has found that an alkaline solution of pyrogallie acid(4) is very well fitted for the absorption of oxygen, and that the decomposition of air founded thereupon is especially applicable when a great number of analyses of air are to be executed rapidly and easily, but with a certain degree of accuracy. The air to be examined (confined over mercury) is agitated with from  $\frac{1}{30}$  to  $\frac{1}{40}$  its volume of solution of potassa of spec. grav. 1.4, which removes the carbonic acid and aqueous vapour; or the air may be agitated with solution of potassa, after drying with chloride of calcium, and the carbonic acid thus determined. The solution of potassa is then mixed with half its volume of a solution containing 1 grm. of pyrogallie acid in 5 or 6 cub. cent. of water, and this mixture is agitated with the gas until the oxygen is completely absorbed, which is the case in a few minutes. Eleven analyses, conducted in this manner (some of them by different individuals), gave between 20.8 and 21.0 volumes of oxygen in 100 of the air after treatment with potassa. Ordinary gallic acid may be employed for this purpose, but acts much more slowly; tannic acid requires a still longer time.

**Carbonic Acid.**—Mulder(5) has described an apparatus for the estimation of carbonic acid in the carbonates. It is composed, 1, of a narrow Welter's safety-tube (for the introduction of the decomposing acid) provided with a bulb; this tube is connected by a cork with 2, a U-shaped tube with narrow vertical limbs, and a wide horizontal portion (to contain the substance); to this is attached, by means of a cork, 3, an ordinary chloride-of-calcium-tube, the end of which is bent at right angles; then follow, connected by caoutchouc, 4, a potash-apparatus, 5, a potash-tube, and lastly, 6, a second chloride-of-calcium-tube. The only weights required are, that of the substance which is introduced into the U-shaped tube 2, and that of the apparatus 4 and 5 containing potash, both before and after the operation. The use of this apparatus requires no farther description.

H. Ludwig(6) proposes, for the determination of carbonic acid in

(1) Described by Kolbe in Liebig, Poggendorff and Wöhler's Handwörterb. d. Chem. II, 1051.

(2) Annual Report for 1849, III, 390.

(3) Ann. Ch. Pharm. LXXVII, 107; Chem. Gaz. 1851, 53; Compt. Rend. XXXII, 54; Instit. 1851, 34; J. Pharm. [3] XIX, 155.

(4) By the dry distillation of the so-called Chinese nut-galls in small retorts, we obtain a very concentrated solution of pyrogallie acid, which, when evaporated on a water-bath, leaves a quantity of brown crystallized acid, amounting to about 15 per cent of the nut-galls employed.

(5) Scheikund. Onderzoek, V, 7. Stuck, 417.

(6) Arch. Pharm. [2] LXIV, 257. Independently of the uncertainty attaching to all indirect analyses, the acetate of potassa is not fit for accurate weighing; and, moreover, the formation of an acid salt may very possibly introduce an error into the results.

the neutral carbonates of potassa, soda, baryta, or lime, to decompose the weighed compound with acetic acid, to weigh the acetate, after complete desiccation, and to calculate the quantity of carbonic acid from the difference of weight (occasioned by the difference between the atomic weights of acetic and carbonic acids).

Carbonic acid.

J. J. Pohl(1) has described a process for the estimation of carbonic acid in beer. For this purpose he employs the carbonic acid apparatus (with two small flasks) introduced by Will and Fresenius, in which he extracts the carbonic acid from the beer; previously weighed therein, by adding common salt and heating the apparatus in a water-bath to  $100^{\circ}$ . In other respects the operation does not differ from an ordinary determination of carbonic acid.

**Boracic Acid.**—H. Rose(2) has described a series of experiments upon the quantitative determination of boracic acid. He found that this acid was for the most part, volatilized by the repeated evaporation of its aqueous solution, and that this volatilization was prevented by the fixed alkaline carbonates, but not by ammonia. If an aqueous solution of boracic acid be evaporated to dryness with sal-ammoniac, and the residue ignited, with exclusion of air, a greyish-white infusible residue of nitride of boron is left. Less nitride of boron is obtained by heating together dry boracic acid and sal-ammoniac, and none whatever when the dry mass is ignited with access of air. Nitrate of ammonia produces no nitride of boron, but does not prevent the partial volatilization of the boracic acid any better than free ammonia or sal-ammoniac. Moreover, boracic acid cannot be determined by evaporation with a weighed quantity of oxide of lead or of tribasic phosphate of soda ( $3 \text{ NaO}, \text{PO}_5$ ). Its determination is best effected by adding a weighed quantity of dry carbonate of soda, evaporating, igniting, and weighing. The amount of carbonic acid is determined in the ignited mass, and the quantity of the boracic acid ascertained by deducting that of the soda and carbonic acid. This process, it is true, is applicable only in the case, which perhaps never occurs, where boracic acid is to be determined in an aqueous solution containing no other substance. The quantity of carbonic acid which boracic acid is capable of expelling, when fused with alkaline carbonates, always increases with the temperature and with the duration of the experiment.

The best method of separating boracic acid from the bases, consists in expelling it as terfluoride of boron, by heating with hydrofluoric acid, and afterwards with concentrated sulphuric acid; it may also be separated, though less conveniently, as boracic ether, by long and careful heating with concentrated sulphuric acid, and repeated addition.

(1) Denkschriften d. Mathem.-Naturw. Classe der Wien. Academie, II.

(2) Pogg. Ann. LXXX, 262; Berl. Acad. Ber. 1850, 201; Ann. Ch. Phys. [3] XXXI, 361; Instit. 1851, 14; Chem. Gaz. 1850, 381.



Boracic  
acid.

of alcohol. There exists no insoluble form of boracic acid in which it can be entirely separated from its solutions; even the borofluoride of potassium, proposed for this purpose by Berzelius(1), does not furnish accurate results, although, according to Rose, it is entirely insoluble in alcohol. When borate of soda is treated with hydrofluoric acid, borofluoride of sodium is obtained, which is not entirely converted into borofluoride of potassium by treatment with acetate of potassa, and, when boiled with carbonate of lime is only partly converted into borofluoride of calcium, which remains mixed with the borofluoride of sodium. On this account, we cannot succeed in separating the borates and fluorine-compounds, which occur together in many silicates, by adding carbonate of lime to the solution acidified with nitric acid.—Boracic acid may be separated from phosphoric acid, either by treating the feebly-acid solution with carbonate of baryta(2), or by precipitating the phosphoric acid as phosphate of magnesia-ammonia. (Phosphate of baryta is slightly soluble in borax-solution; phosphate of magnesia-ammonia retains a trace of boracic acid). All insoluble borates are so completely decomposed by fusion with alkaline carbonates, that the boracic acid may be entirely dissolved out of the fused mass by water. Baryta, strontia, and lime are easily separated from boracic acid by sulphuric acid, with or without addition of alcohol; magnesia may be precipitated as phosphate; alkalis can only be separated from boracic acid by a process involving the volatilization of the latter as terfluoride of boron or boracic ether.

**Analysis of Borates.**—E. Schweizer(3), in order to estimate the bases when in combination with boracic acid, converts them into chlorides by evaporation with excess of hydrochloric acid, and calculates their amount from that of the chloride of silver obtained from these chlorides. The analysis of borax by this method furnished correct results.

**Phosphorus.**—Lassaigne(4) has shown, by experiments upon dogs, that in poisoning with phosphorus, the greater part was expelled by vomiting; the phosphorus was detected in the mixture, even after standing for five days, by treatment with ether.—Gorup-Besanez(5) describes the method which he followed for the detection of phosphorus in a case of poisoning.

**Phosphoric Acid.**—For the detection of phosphoric acid when in combination with alumina, Kobell(6) dissolves the compound in as little potassa as possible, then adds an equal volume of solution of

(1) *Léhrb.* 3. Aufl. 84.

(2) Compare Annual Report for 1849, III, 393.

(3) From the *Mittheil. der Naturf. Gesellschaft in Zürich*, 1850.

(4) *J. Chim. Méd.* [3] VI, 206.

(5) *Repert. Pharm.* [3] VI, 313.

(6) *J. Pr. Chem.* L, 495.

soluble glass, acidulates with acetic acid, and heats the liquid to boiling. If phosphoric acid be present, acetate of lead produces, in the filtrate, a precipitate of phosphate of lead which may be recognized by its behaviour before the blow-pipe.

**Sulphur.**—H. Debus(1) describes the following process for the estimation of sulphur in organic compounds.—1 equiv. (149 parts) of bichromate of potassa, purified by recrystallization, is dissolved in water, together with 2 equivs. (138 parts) of carbonate of potassa, or (106 parts) carbonate of soda; the mixture is evaporated to dryness, the powdered, lemon-yellow mass ignited in a Hessian crucible, and introduced into a glass tube from which it may easily be transferred to the combustion-tube. A layer of 3 or 4 inches of this mixture is introduced into the combustion-tube, the substance poured in upon it, and then another layer of several inches of the mixture. Solid compounds are mixed with an iron-wire twisted into the form of a corkscrew. The empty portion of the tube is now filled with the mixture, and heat applied. When the tube is ignited throughout its whole length, a slow stream of oxygen is passed through it for half-an-hour or an hour. When cool, the tube is freed from adhering ashes, and broken, over a sheet of paper, into several pieces, which are digested with water until the mass is completely dissolved. The solution thus obtained is strongly acidified with hydrochloric acid, heated with alcohol until the chromic acid is entirely reduced, and filtered from the undissolved sesquioxide of chromium. This latter (which contains some sulphuric acid), after washing, first with water acidulated with hydrochloric acid, and subsequently with alcohol, is dried, and fused with a mixture of 1 part of chlorate of potassa, and 2 parts of carbonate of potassa; the mass is dissolved in dilute hydrochloric acid, the chromic acid reduced by alcohol, and this solution then added to the main portion. From this the sulphuric acid is precipitated, at a boiling heat, by chloride of barium. Debus satisfied himself that no sulphur escapes during the oxydation, but found that when carbonate of soda is employed, the amount of sulphur may be rather too high (since that salt often contains from 0.001 to 0.002 of hyposulphite).

**Thionic Acids.**—According to Fordos and Gélis(2) pentathionic acid is decomposed by boiling with potassa, a hyposulphite being formed; tetrathionic and trithionic acids, when thus treated, give sulphite of potassa in addition. (See p. 181). In order to detect and estimate sulphurous acid in the presence of hyposulphurous acid, the baryta-salt is treated as follows. About 1 grm. of the salt is retained in ebullition for some time with 4 or 5 grms. of hydrate of potassa and 50 grms. of water; to the cooled liquid, acetate of zinc is added until all the potassa is neutralized; if free hydrochloric or acetic acid

(1) Ann. Ch. Pharm. LXXVI, 88.

(2) Loc. cit. p. 181.

**Thionic  
acids.**

were employed for this latter purpose, great care would be requisite to avoid an excess: The neutralized fluid is treated with a graduated solution of iodine, and the oxide of zinc is then dissolved in dilute hydrochloric acid. If there be no sulphite present, no precipitate (of sulphate of baryta) will be formed in this part of the process, and the quantity of hyposulphite which is present may be inferred from that of the iodine used. Should the solution contain a sulphite, a few drops of a baryta-salt must be added after the treatment with iodine and acidification of the liquid, and the sulphate of baryta collected, in order that the amount of the sulphite may be calculated from it. In this way, the amount of iodine which was consumed by the sulphurous acid is ascertained; this amount is deducted from the total quantity of iodine employed, and the weight of the hyposulphite calculated from the difference.—In order that the somewhat sparingly soluble sulphite of zinc may be entirely decomposed by the iodine, it is necessary, after neutralizing the solution with acetate of zinc, to add the iodine-liquor gradually.

**Iodine.**—For dissolving iodides out of a mixture of these salts with chlorides, bromides, sulphides, sulphites, and hyposulphites, Casa-seca(1) recommends acetic ether instead of common ether, which was formerly proposed for this purpose. The residue obtained by evaporating the solution, when dissolved in water, and treated with starch-powder and nitric acid, exhibits the pure reaction of iodine.

Rabourdin(2) takes advantage of the property possessed by chloroform, of dissolving free iodine with a violet colour, in order, approximatively, to determine the latter substance in organic compounds, and particularly in cod-liver-oil. The oil (50 grms.) is heated with hydrate of potassa (5 grms.) and water (15 grms.), in an iron vessel, until the organic matter is completely destroyed; the carbonaceous mass is washed with as little water as possible, the solution mixed with concentrated sulphuric acid, and when cool, 10 drops of nitric acid are added to it. If the liquid be now shaken with (4 grms.) chloroform, and allowed to stand, a layer is formed, having a violet colour from the intensity of which the amount of iodine may be inferred by comparison with a similar solution of known strength.—Chloroform even withdraws the iodine from an aqueous solution; if the chloroform contain ether, the colour is not violet, but when little ether is present, wine-red, and with a larger quantity, caramel-red.

In order to detect iodine in ashes or mineral waters, E. Marchand(3) mixes the aqueous solution to be tested (in a glass which may be closed), first with some powdered starch (not with the paste, which is less easily deposited), then with excess of hydro-

(1) *Compt. Rend.* XXX, 821.

(2) *Compt. Rend.* XXXI, 784; *J. Pharm.* [3] XIX, 13; *Ann. Ch. Pharm.* LXXVI, 375.

(3) *J. Pharm.* [3] XVII, 358.

chloric acid, and afterwards with about 0.001 grm. of chlorate of potassa. After shaking and allowing to stand, a rose-red tint is perceptible, even when the experiment is made with 10 cub. cents. of a liquid containing only  $\frac{1}{500000}$  of an iodide.

Bromine.

**Bromine.**—Figuier(1) determines the amount of bromine contained in a liquid, by means of a standard solution of chlorine, which is gradually added, until, after decolorizing the liquid by ebullition, a fresh addition of chlorine produces no yellow colour. . . .

**Fluorine.**—Terfluoride of silicon, according to H. Rose(2), attacks glass, though very feebly. When, therefore, silicates containing fluorine, or specimens of rocks in which phosphates containing fluorine (particularly apatite) occur, together with silicate, are decomposed, in the powdered state, with concentrated sulphuric acid, the glass is slightly etched, as is perceived by breathing upon it. Terfluoride of silicon, however, is decomposed by a very small quantity of moisture; hence, on heating the decomposed mass, terfluoride of silicon is first evolved, and then hydrofluoric acid, which etches the glass.

**Nitric Acid.**—For the detection of very small quantities of nitric acid, J. Higgin(3) makes use of the following process. The solution to be tested is mixed with  $\frac{1}{6}$  of its vol. of concentrated sulphuric acid, heated nearly to boiling, and allowed to cool; a drop of starch-paste is then added, and afterwards several drops of a solution of iodide of potassium, so dilute that it will not give the blue colour on adding sulphuric acid alone; 1 part of the iodide should be dissolved, for this purpose, in 20 parts of water. The solution of iodide of potassium is to be added to the cold mixture, which must not contain too much sulphuric acid. When nitric acid is present, the coloration becomes visible within ten minutes; but, in the absence of nitric acid, the mixture also becomes blue on standing for an hour in contact with the air, since iodine is liberated from the hydriodic acid.

**Ammonia.**—Boussingault(4) determines the ammonia in urine by the following method, in order to exclude the possibility of error arising from the decomposition of the urea. He found that all the ammonia was evolved from ammoniacal salts in aqueous solution (and from phosphate of magnesia-ammonia, dissolved in acidulated water) by evaporating to dryness *in vacuo*, at 40° or 45°, with hydrate of lime or carbonate of soda. Urea, treated in a similar manner, suffers no decomposition. Boussingault allows the urine under examination to flow into a flask, heated to 40° or 45°, and containing hydrate of lime or carbonate of soda; from this flask

(1) Compt. Rend. XXXI, 898; Instit. 1851, 13.

(2) Pogg. Ann. LXXX, 406.

(3) Chem. Gaz. 1850, 249; Pharm. J. Trans. X, 84.

(4) Ann. Ch. Phys. [3] XXIX, 472; J. Pr. Chem. LI, 281.

**monia.** a tube passes into a vessel containing sulphuric acid, of known strength, beneath the surface of which the tube dips; this vessel, again, is connected by a tube with the receiver of an air-pump. The different parts of this apparatus are provided with stop-cocks, so that the urine may be entirely rinsed into the flask through a funnel-tube, likewise furnished with a stop-cock, before putting the flask into permanent communication with the exhausted receiver. The contents of the flask soon become dry; air is then allowed to flow through the apparatus, and the strength of the sulphuric acid determined, in order to ascertain how much ammonia it has absorbed, and therefore how much was contained in the urine.—Millon's statement(1), that, by evaporating urine upon the water-bath, from  $\frac{1}{4}$  to  $\frac{1}{2}$  its nitrogen was evolved, has been found by Boussingault to be entirely groundless, provided too great a vol. of liquid be not evaporated at once.

**Hydrocyanic Acid.**—Liebig(2) has published a process for the determination of hydrocyanic acid in the medicinal acid, in bitter-almond- and laurel-waters. It depends, upon the circumstance that 1 equiv. of cyanide of potassium forms, with 1 equiv. of cyanide of silver, a soluble double compound, which is not decomposed by an excess of alkali. The liquid containing hydrocyanic acid is mixed with solution of potassa, to strongly alkaline reaction, and a graduated silver-solution is then added, until a permanent cloud begins to appear. 1 equiv. of silver employed in the standard solution corresponds exactly to 2 equivs. of hydrocyanic acid. The presence of formic or hydrochloric acid in the hydrocyanic acid does not influence the determination of the latter in an alkaline solution. Bitter-almond-water, which is turbid from the presence of drops of oil, should, before testing, be mixed with 3 or 4 vols. of water, to render it clear, since otherwise the limit of the reaction cannot be accurately discerned.

**Decomposition of Silicates.**—According to H. Wurtz(3), the decomposition of silicates for the determination of alkalies may be effected by fusion with chloride of barium, or with a mixture of single equivs. of chlorides of barium and strontium, as completely as with hydrate or carbonate of baryta. The finely-powdered mineral is mixed and fused, for twenty or thirty minutes, with 4 or 5 times its weight of the chloride; the excess of this salt is then dissolved out by water, the residue decomposed with concentrated hydrochloric acid, the silica separated as usual, and the solution treated in the ordinary manner; after removing the baryta by sulphuric acid.

**Potassa and Soda.**—H. Rose(4) has shown, that potassa and soda are completely precipitated from their solutions by hydrofluosilicic

(1) Annual Report for 1849, III, 384; Millon's reply J. Pharm. [3] XVIII, 360.

(2) Ann. Ch. Pharm. LXXVII, 102; J. Pharm. [3] XIX, 297.

(3) Sill. Am. J. [2] X, 323.

(4) Pogg. Ann. LXXX, 403; Berl. Acad. Ber. 1850, 272; J. Pr. Chem. LI, 176.

acid, on adding to the liquid an equal vol. of alcohol. When the precipitate is to serve for the estimation of these bases, it is washed with a mixture of equal vols. of alcohol and water, and dried at 100°.

Potassa  
and soda.

—Since, according to Rose's observations, hydrofluosilicic acid, when long kept in glass vessels, abstracts from them a certain amount of alkali, lime, and oxide of iron (which are precipitated as silicofluorides on adding alcohol), it is necessary, for accurate quantitative determinations, that the hydrofluosilicic acid should always be freshly prepared, unless it can be kept in vessels of platinum or silver.

**Soda as a Reducing Agent.**—R. Wagner(1) found that, by the protracted fusion of soda before the blow-pipe, until the mass was absorbed by the charcoal, some cyanide of sodium was produced, to which he ascribes, in part at least, the reducing action of the flux.

**Lithium.**—Chapman(2) states that lithium may easily be distinguished, before the blow-pipe, in presence of sodium, by fusing the mixture containing the two bases with chloride of barium, on a loop of platinum-wire; when first, the yellow colour of the soda-flame, then the greenish-yellow tint due to baryta; and, lastly, the red colour of the lithia, especially if a clean, and not too large, blue flame be employed, may be perceived.

**Magnesia. Separation from the Alkalies.**—Ebelmen(3) describes a process for the separation of magnesia from the alkalies, which is founded upon the decomposition of the sulphates of those bases by carbonate of baryta, dissolved in free carbonic acid. The solution of the salts is mixed with carbonate of baryta, and carbonic acid passed through it until a sample of the filtered liquid is found to contain baryta; the whole is then filtered, and evaporated to dryness; the residue is heated, in order to convert the bicarbonates into neutral carbonates, and treated with water, which dissolves only the carbonates of the alkalies. For the estimation of alkalies in silicates dissolved by hydrofluoric acid, Ebelmen makes use of the same process, except that, in presence of alumina (which, when precipitated by carbonate of baryta, carries down with it a little alkali), he separates this by adding ammonia or carbonate of ammonia, boils the filtrate with excess of carbonate of baryta, until the whole of the sulphate of ammonia is decomposed, and treats the liquid, as above, with carbonic acid.

**Baryta.**—According to H. Rose(4), baryta is more completely precipitated by hydrofluosilicic acid from a solution mixed with alcohol than from an aqueous solution; on which account a certain quantity of alcohol should be added in the separation of baryta from strontia, in the form of silicofluoride of barium. The latter is dried at

(1) J. Pr. Chem. XLIX, 191.

(2) Chem. Gaz. 1850, 441.

(3) Ann. Ch. Phys. [3] XXX, 324; J. Pr. Chem. LI, 439; Chem. Gaz. 1851, 94.

(4) Loc. cit. p. 404.

**ontia.** 100°. With respect to the hydrofluosilicic acid employed for this purpose, the observation at p. 404 will apply.

**Strontia.**—In reply to Muspratt's(1) observations upon the behaviour of strontia-salts before the blow-pipe, Chapman(2) states that even insoluble compounds of strontia, such as celestine and strontianite, exhibit, *per se*, at least after some time, the red colour of the flame. Chloride of barium, however, prevents the production of the carmine-red colour, even though it be present in smaller quantity than 50 per cent; the presence of soda does not interfere with this reaction; for a mixture of equal parts of chloride of barium and carbonate of soda shows, at first, the yellow soda-flame, and subsequently, in consequence of the volatilization of the chloride of sodium, the pale green flame of baryta. With a mixture of chloride of strontium and carbonate of soda, the strontia-flame is likewise obtained after prolonged blowing.

**Zinc.**—E. Schmidt(3) has found that, in zinc-ores which, like siliceous calamine, contain both carbonate and silicate of zinc, the oxide existing in combination with carbonic acid, may be dissolved out by digesting the ore, previously ignited, with solution of carbonate of ammonia containing free ammonia, which leaves the silicate untouched. Acetic acid cannot be employed for this purpose, since it always decomposes more or less of the silicate of zinc.

**Iron.**—Fr. Penny(4) describes a process for the rapid determination of iron in iron-ores, similar to that furnished by Marguerite(5). Instead of the permanganate of potassa, he prefers a graduated solution of bichromate of potassa, which he adds to the diluted solution containing the iron in the state of protoxide, until ferrieyanide of potassium shows that the conversion into sesquioxide is complete. Penny's process is therefore the reverse of that proposed by Schwarz(6) for the determination of chromium. Penny prefers the bichromate of potassa to the permanganate, as an oxydizing agent, because the solution of the latter is gradually decomposed when kept.

**Separation of Iron and Manganese.**—O. Henry(7) has described a process for the separation of iron from manganese, which depends essentially upon the precipitation of the sesquioxide of iron from a slightly acid solution, by heating. Henry throws down the rest of the sesquioxide of iron by adding ferrocyanide of potassium as long as the precipitate is blue or blueish, after which, the manganese comes down as a reddish-white precipitate. All that is useful in this process has been practised already for some time.—Lamy(8) describes

(1) Annual Report for 1849, III, 405. (2) Chem. Gaz. 1850, 427.

(3) J. Pr. Chem. LI, 257.

(4) Chem. Gaz. 1850, 330; Instit. 1850, 327.

(5) Ann. Ch. Phys. [3] XVIII, 244.

(6) Annual Report for 1849, III, 406.

(7) J. Chim. Méd. [3] VI, 566.

(8) J. Chim. Méd. [3] VI, 693.

the methods of separation, likewise already known, by means of benzoate or succinate of ammonia, and carbonate of baryta.

**Separation of Sesquioxide of Iron from Alumina, Berylla, Zirconia and Sesquioxide of Chromium.**—L. E. Rivot(1) recommends, for the separation of several heavy metallic oxides, especially those of iron and tin, from the earths, their reduction by hydrogen, at a high temperature. The mixed precipitate produced by ammonia, containing the oxides to be separated, is dried, ignited, together with the filter-ash, in a platinum crucible, finely powdered, and, after weighing, ignited in a small weighed porcelain boat, placed in a tube of porcelain through which a slow stream of dry hydrogen is passed, as long as any formation of water takes place. An hour suffices for complete reduction. The little boat is allowed to cool in the stream of hydrogen, and weighed. From the loss of weight, which represents the amount of oxygen contained in the sesquioxide of iron, the amount of this oxide can be calculated with accuracy only when that of the earths is relatively small, and the stream of gas has not been too rapid. The mixture of metallic iron with the earths is digested, in the cold, for twenty-four hours, with very dilute nitric acid (1 part of acid with at least 30 parts of water) until the earthy residue is white. The solution is filtered, and the sesquioxide of iron precipitated from the previously heated filtrate, by ammonia. From a mixture of oxides which have not been simultaneously precipitated, a little of the earth may easily be carried forward by the stream of gas; this applies especially to berylla and alumina, but not so much to zirconia, on account of its greater specific weight.—Nickel and cobalt may also be removed by dilute nitric acid from a mixed precipitate containing the oxides of these metals together with alumina, after ignition in a stream of hydrogen. Rivot exposes finely-powdered chrome-iron ore, for four hours, to a bright red heat, in a current of hydrogen, when all the sesquioxide of iron is reduced. The loss of oxygen is determined, and the residue treated for twenty-four hours with dilute nitric acid, which dissolves all the iron together with a trace of lime; whilst sesquioxide of chromium, alumina, silica, and even lime, remain undissolved.

**Tin.**—Ch. Mène(2) describes a process for the determination of tin by means of a graduated solution of sesquichloride of iron; it is based upon the decoloration of the latter by protochloride of tin ( $\text{Fe}_2\text{Cl}_3 + \text{SnCl} = 2 \text{FeCl} + \text{SnCl}_2$ ). 1 or 2 grms. of the substance to be analyzed are heated, in a flask capable of containing about  $\frac{1}{2}$  litre, with 1 part of nitric acid and 6 parts of hydrochloric acid, until all

Separation of sesquioxide of iron from alumina, berylla, zirconia and sesquioxide of chromium.

(1) Ann. Ch. Phys. [3] XXX, 188; Ann. Ch. Pharm. LXXVIII, 212; J. Pr. Chem. LI, 338.

(2) Compt. Rend. XXXI, 82; Instit. 1850, 233; Laur. and Gerh. C. R. 1850, 266; J. Pr. Chem. LI, 163.



**Tin.** the tin is converted into bichloride. Metallic zinc is now added, which renders the yellow liquid colourless, converting the bichloride of tin into protochloride, whilst the excess of hydrochloric acid prevents the precipitation of metallic tin. The graduated solution of sesquichloride of iron (best prepared by boiling colcothar with hydrochloric acid) is now added from a burette, until a decided coloration is perceived, for which one drop of the sesquichloride in excess suffices. Should the alloy contain copper, lead, or any other metals not soluble in hydrochloric acid, these are precipitated by the metallic zinc without alteration in the process; arsenic, however, must be removed from the alloy by prolonged exposure to heat in a crucible lined with charcoal.

**Discrimination of Tin, Antimony and Arsenic.**—For the separation of tin and antimony, Fleitmann(1) decomposes the feebly (hydrochloric) acid solution of the two metals, with metallic zinc, when both are precipitated (the separation of the antimony being attended by the evolution of antimonetted hydrogen, which may be recognized by the black spots, insoluble in hypochlorite of soda, which its flame deposits upon a porcelain surface). If the black metallic powder precipitated by the zinc be boiled with strong hydrochloric acid, the tin alone is dissolved, as protochloride, and may be recognized by the brown precipitate with sulphuretted hydrogen. The detection of arsenic in presence of antimony depends upon the circumstance that a strongly alkaline solution of the latter metal, when heated with finely-divided zinc, evolves only pure hydrogen, whilst, on the other hand, an alkaline solution of arsenic evolves also arsenetted hydrogen, which may be most easily recognized by its blackening distinctly a strip of paper moistened with a silver-solution.—The ordinary Marsh's test can only be applied (when the evolution of gas is slow), if a stream of pure hydrogen be passed from a second evolution-bottle through the alkaline liquid.

**Separation of Binoxide of Tin and Silica.**—According to Rivot's method(2), a strongly ignited and weighed mixture of binoxide of tin and silicic acid is heated to dull redness in a stream of hydrogen, when the reduction proceeds very rapidly. The amount of binoxide of tin can only be approximately calculated from the weight of the grey residue, since some silica may easily be carried forward by the stream of gas. It is better, therefore, to dissolve the tin in *aqua-regia*, and to estimate the undissolved silica. The tin-solution is mixed with ammonia and a sufficient quantity of sulphide of ammonium, and the bisulphide of tin then precipitated by hydrochloric acid. In tin-ores, also, the metal may, in this way, be easily separated from the gangue.

(1) Ann. Ch. Pharm. LXXVII, 126.

(2) Loc. cit. p. 407.

**Detection of Metallic Poisons in Judicial Analyses.**—Gaultier de Claubry(1) describes a process which he has invented for the detection of metallic poisons (silver excepted) in judicial cases. It appears to differ from others which have been proposed, only in that Gaultier de Claubry decomposes the organic matter by hydrochloric acid, with addition of nitric acid, and, after concentrating the solution thus obtained, and expelling the excess of acid, precipitates any metals which may be present by means of a galvanic current. After ten or twelve hours, the platinum-plate becomes covered with the metal which was present in the solution; the deposit is rinsed with a wash-bottle, and dissolved in nitric acid for farther examination. This method is applicable in all cases, but particularly for the detection of copper in bread. In examining for zinc, a plate of tin or platinum must be used for the anode.

Detection of metallic poisons in judicial analyses.

**Silver. Gold.**—Cauvy(2) has described an arrangement which facilitates the quantitative determination of gold or silver before the blow-pipe.

**Analysis of Ashes.**—Strecker(3) has submitted to a comparative examination the different methods of preparing ashes for analysis, with especial regard to the carbonization of organic substances as proposed by H. Rose(4). He found, as we have already noticed briefly in the Annual Report for 1849, III, p. 415, that the observation respecting the retention of the ash-constituents by the charcoal, which H. Rose has adopted as the basis of his views concerning the form of combination of the inorganic substances in animals and vegetables, is only true in cases where the quantity of the charcoal greatly exceeds that of the inorganic substances; he finds, moreover, that the charcoal furnished by the same organic substance may be freed from inorganic matters so much the more completely, the greater the quantity of incombustible matters which it contains. Thus the charcoal obtained from the entire blood, containing from 12 to 15 per cent of ash, allows only  $\frac{1}{3}$  of that quantity to be extracted by water and hydrochloric acid, whereas, if the albumin be separated by coagulation at 100°, and the solution evaporated, a charcoal is obtained, containing above 80 per cent of ash, which may be entirely extracted by water and hydrochloric acid. Direct experiments with sugar and casein, which were carbonized together with salts (acetate of potassa, phosphate of soda, sulphate of magnesia, chlorides of potassium and sodium) likewise showed that these salts, or their bases, were retained by the charcoal more completely and pertinaciously, the smaller the quantity in which they were present. Strecker compares this to the behaviour of an alloy of gold and silver with nitric acid, which

(1) J. Pharm. [3] XVII, 125.

(2) Instit. 1850, 181.

(3) Ann. Ch. Pharm. LXXIII, 339.

(4) Annual Report for 1847 and 1848, II, 237; Annual Report for 1849, III, 413.

analysis of  
ashes.

either dissolves the latter metal, or leaves it untouched, according to the relative quantities of the metals. He shows that the composition of an ash found by Rose's method is incorrect, as regards the amount of chlorine, in all cases where the charcoal can only be partially exhausted by water and hydrochloric acid, and that the quantity of the oxides must always be too great, since the deficient chlorine is replaced, in the calculation, by oxygen.—If sugar be carbonized together with tribasic phosphate of soda, and the charcoal lixiviated with water, the solution is found to contain carbonate and pyrophosphate of soda, whence it may be inferred that the presence of carbonates in the aqueous solution of carbonized substances does not always indicate the existence of salts of carbonic acid or of organic acids in the animal or vegetable substance. Finally, Strecker has shown that carbonized blood and bile contain small quantities of metallic cyanides, and that carbonized ox-bile contains also metallic sulphides. For the incineration of organic substances, Strecker prefers the employment of a muffle, which had been previously recommended by Erdmann. The muffle is closed in front by a loosely-fitting clay cover, which allows a sufficient circulation of air to complete the combustion of the carbon within twelve hours, without any danger of volatilizing the chloride of sodium. The incineration proceeds best at 3 or 4 inches from the anterior opening. In order to avoid any loss whatever of chlorine or phosphoric acid, Strecker recommends the following process of incineration. The organic substance, previously dried, is gently carbonized in a porcelain or platinum dish over the spirit-lamp. The coal is moistened with a concentrated solution of pure hydrate of baryta, which is employed in such quantity that the ash remaining after incineration may contain about half its weight of baryta. The moistened charcoal is again dried, and burnt in the muffle at as low a temperature as possible; in this way the ash is not fused, but remains voluminous and spongy, so as to allow the complete combustion of the carbon. The incinerated residue, which should contain a considerable excess of carbonate of baryta, is finely powdered and thoroughly mixed. Strecker again calls attention to the presence of cyanates in the ashes, especially of animal substances; the simplest method of decomposing the cyanates consists in moistening the ashes with water, and gradually heating to redness.

Staffel(1) has made observations similar to those of Strecker in reference to H. Rose's method; in the ash-analyses conducted by Staffel, the process proposed by Wackenroder(2) was adopted, with this difference, however, that the carbonized substances were exhausted with boiling water before incineration, in order to avoid, as far as

(1) Arch. Pharm. [2] LXIV, 1, 129.

(2) Annual Report for 1847 and 1848, II, 240.

possible, the volatilization of the chlorides. Staffel mixed the difficultly combustible charcoal obtained from flesh with acetate of lime, according to Wackenroder's directions.

Analysis  
of ashes.

R. Weber(1) states, that in the ash-analyses conducted by himself according to H. Rose's method, several inaccuracies occurred in the estimation of acids, and particularly of hydrochloric acid; he observed, moreover, that a loss of chlorine took place in the carbonization of sugar with chloride of potassium, which differs from the statement of Strecker, who recovered all the chlorine. If, however, a sufficient quantity of alkaline carbonate be present, no chlorine escapes.

H. Rose(2) himself has likewise demonstrated by numerous experiments, in part conducted by Weber, that when inorganic salts are mixed with relatively small quantities of organic matter, they may be almost entirely extracted by solvents from the carbonized mass, whereas, if a very large quantity of organic matter be present, the salts are protected by the surrounding charcoal from the action of the solvents. Since, in consequence of these observations, the inaccuracies become manifest which attach to the method formerly described by Rose for the analysis of ashes, he has now(3) brought forward the following modification of the process.

The organic substance, as in the original method, is carbonized at a gentle heat, and the finely-powdered charcoal, intimately mixed with 20 or 30 grms. of spongy platinum, is completely incinerated by small portions at a time, in a thin platinum dish, over the spirit-lamp. When 100 grms. of substance are employed, the combustion of the charcoal in this way is terminated in two or three hours. In order that no sand or clay may be left with the ash, the substances, especially if of vegetable origin, must be carefully purified; seeds are cleaned by repeatedly stirring with water; the separated dust is then removed by a strainer, and lastly, the adhering solid impurities are wiped off by rubbing on linen.

The grey platiniferous mass obtained by incineration, is heated in an air-bath to 120° until its weight is constant. It is then treated with hot water, the aqueous solution evaporated to dryness, the residue gently ignited and weighed. If the carbonic acid is to be determined in the residue, it is necessary to pass carbonic acid gas into the solution previously to evaporation. If the weight of the dry residue amount to several grms., different portions may be employed for the determination of the various constituents, but if there be only a small quantity disposable, all the substances are determined in one portion, as follows.—The aqueous solution is acidified with dilute nitric acid (which may be effected in an apparatus for determining the

(1) Pogg. Ann. LXXXI, 402.

(2) Pogg. Ann. LXXIX, 398.

(3) Pogg. Ann. LXXX, 94; Berl. Acad. Ber. May, 1850, 165 (in abstr.); J. Pr. Chem. L, 434; Instit. 1850, 316.

lysis  
has.

carbonic acid), and any separated silica having been filtered off, the chlorine may be determined in the liquid. After removing the excess of silver by hydrochloric acid, the solution is evaporated to dryness, and the silica separated as usual. The liquid filtered from the silica is mixed with excess of ammonia, the precipitated earthy phosphates filtered off, washed a little, ignited, weighed, and their weight deducted from that of the constituents soluble in water; for farther analysis, they are then added to that portion of the ash which is soluble in nitric acid. The filtrate from the earthy phosphates is mixed with oxalic acid, in order to determine any lime which may be present; the sulphuric (oxalic) and phosphoric acids are now precipitated by chloride of barium, the washed precipitate treated with hydrochloric acid, and the undissolved sulphate of baryta determined; after the baryta has been precipitated from the hydrochloric solution by dilute sulphuric acid, the phosphoric acid is determined as phosphate of magnesia-ammonia.—The filtrate from the phosphate and sulphate of baryta is mixed with carbonate of ammonia and free ammonia, to precipitate the excess of baryta, evaporated, and ignited, when the alkalies are left in the form of chlorides.

That part of the ash (containing platinum) which remains after extraction with water, is now treated with hot dilute nitric acid, and thoroughly washed with water containing that acid. The solution contains phosphates of lime, magnesia, and sesquioxide of iron, frequently also traces of manganese, together with nitrates of potassa, soda, lime, and magnesia, but no sulphuric acid or chlorine. It is treated with metallic mercury according to Rose's method(1) for the determination of phosphoric acid, and the bases separated from the latter are determined in the ordinary way. The platinum remaining after exhaustion with water and nitric acid, still retains some silicic acid. It is heated with solution of potassa, filtered off, and washed with hot water. The silicic acid is separated from the alkaline solution in the usual manner; the platinum is dried at 120° and weighed, and thus we ascertain the weight of the ash itself, although not quite accurately, since it is impossible exactly to determine the carbonic acid.—In order to avoid a loss of chlorine during the incineration of ashes which are free from carbonates, Rose proposes to moisten the organic substance with the solution of a weighed quantity of carbonate of soda, and to carbonize it in a platinum crucible. The soda employed is afterwards deducted from that obtained in the analysis.

**Testing of Water.**—A method has been long in use, which was published and patented by Clark(2), for testing, with rapidity

(1) Annual Report for 1849, III, 395.

(2) Repertory of Patent Inventions for 1841; "A New Process for Purifying the Waters supplied to the Metropolis," by T. Clark, London, 1849; "On the Examination of Water of Towns as to its Hardness," &c., by T. Clark, 1847.

and certainty, any water which is to be employed for household or technical purposes, as to its hardness (that is, as to the amount of alkaline earths, alumina, and sesquioxide of iron which it contains). This is effected by means of a graduated soap-solution. J. Moser(1) has accurately described this process according to the directions given by Clark. The following is an extract from Moser's communication upon this subject. When hard water is mixed with a solution of soap, an insoluble soap is precipitated; and if the liquid be shaken, the formation of a lather may be made use of as an indication of complete saturation. When the proper quantity of soap has been added, this lather must remain upon the surface for five minutes. For the execution of this test of hardness, the operator requires a normal solution of soap (the preparation of which is given below), a graduated tube capable of containing 100 cub. cents., a burette, a stoppered bottle, holding 400 cub. cents., and a similar one of 1 litre capacity. The quantity of the metallic oxides precipitable by the soap-solution, is expressed, as in the following table, in degrees, which have been deduced from direct experiments by Clark, since the amount of soap-solution used does not increase in the same ratio as the quantity of salts. The following table shows, for every degree of hardness from 0° to 16°, how many cub. cents. of soap-solution are employed for 100 cub. cents. of the solution (or of the water), corresponding to that degree, in order to produce the characteristic lather.

Testing of  
water.

| Degrees of hardness. | Cub. cent. of soap-solution used. | Difference between each degree of hardness and the following one. | Degrees of hardness. | Cub. cent. of soap-solution used. | Difference between each degree of hardness and the following one. |
|----------------------|-----------------------------------|-------------------------------------------------------------------|----------------------|-----------------------------------|-------------------------------------------------------------------|
| 0° *                 | 1.4                               | 1.8                                                               | 9°                   | 19.4                              | 1.9                                                               |
| 1                    | 3.2                               | 2.2                                                               | 10                   | 21.3                              | 1.8                                                               |
| 2                    | 5.4                               | 2.2                                                               | 11                   | 23.1                              | 1.8                                                               |
| 3                    | 7.6                               | 2.0                                                               | 12                   | 24.9                              | 1.8                                                               |
| 4                    | 9.6                               | 2.0                                                               | 13                   | 26.7                              | 1.8                                                               |
| 5                    | 11.6                              | 2.0                                                               | 14                   | 28.5                              | 1.8                                                               |
| 6                    | 13.6                              | 2.0                                                               | 15                   | 30.3                              | 1.7                                                               |
| 7                    | 15.6                              | 1.9                                                               | 16                   | 32.0                              | —                                                                 |
| 8                    | 17.5                              | 1.9                                                               |                      |                                   |                                                                   |

\* Distilled water.

In applying this test, the large bottle is half-filled with the water to be examined, and shaken strongly and repeatedly, the air being from time to time sucked out of the bottle with a glass tube. In this way we remove from the water the dissolved carbonic acid, which would notably influence the result. 100 cub. cents. of this water are now introduced into the bottle of 400 cub. cents. capacity, and the soap-solution is dropped in from the burette. When 1 cub.

Testing of  
water.

cent. has been added, the bottle is shaken, and in this way the experiment is conducted, until bubbles of lather are formed after shaking. As soon as the lather appears in fine bubbles, the bottle is inclined, in order to ascertain whether the lather remains over the surface for five minutes; if so, the test is completed. The lather must re-appear when the bottle is again shaken after half-an-hour, or even after four hours.

In order to graduate the soap-solution (32 cub. cents. of which yield the lather with 100 cub. cents. of water of 16° of hardness), 0.228 grm. of doubly-refracting Iceland spar is dissolved in hydrochloric acid, the solution completely freed from excess of acid by evaporation, and diluted to the volume of 1 litre. This solution represents a water of 16° hardness. The normal soap-solution is prepared with a hard soda-soap, which is as free from water as possible, and gives thin shining scales when scraped with the nail. 6.25 to 6.3 grms. of such a soap are required, on an average, for 1 litre of solution. The solvent employed is spirit of spec. grav. 0.92 at 15°·5 (of 56.16 per cent.). 32 cub. cents. of this (filtered) soap-solution must exhibit the lather with 100 cub. cents. of the above-mentioned lime-solution (of 16° hardness).

D. Campbell(1) found that a solution of sulphate of magnesia alone behaved towards the soap-solution like lime; but that the quantity of soap-solution required by a mixture of the two was somewhat smaller, so that, for example, 100 cub. cents. of a solution composed of equal parts of a normal solution of lime of 16°, and of one of magnesia at 16°, did not require 32 cub. cents., but only 27.9 cub. cents. of soap-solution.—Maumené(2) has likewise pointed out that the lime-soap is not completely insoluble; so that many well-waters, as also solutions of lime-salts, and even of carbonate of lime, when diluted to a certain extent, give no precipitate with a soap-solution. A liquid containing, in 1 litre, less than 0.580 grm. of sulphate of lime, 0.390 grm. of chloride of calcium, or 0.600 grm. of nitrate of lime, gives no longer a precipitate, but merely an opalescence, with a solution of white soap (20 grms. to the litre). When those waters which contain less than the above quantities of lime-salts decompose the soap, with separation of an insoluble compound, it is to be ascribed, according to Maumené, to the amount of silica or alumina which they contain.

**Oxalic Acid.**—According to H. Rose(3), oxalic acid is most safely determined (also in presence of phosphoric acid) from the quantity of metallic gold which it reduces. The reduction of the terchloride of

(1) Phil. Mag. [3] XXXVII, 171; Chem. Gaz. 1850, 347.

(2) Compt. Rend. XXXI, 271.

(3) Pogg. Ann. LXXX, 549; Berl. Acad. Ber. 1850, 358; J. Pr. Chem. LI, 311; Instit. 1851, 120.

gold added for this purpose, however, proceeds easily and rapidly, only when the solution of the oxalate contains no, or very little, free hydrochloric acid. If much free hydrochloric acid be present, the reduction does not take place at all in concentrated solutions, and only after long boiling, in those which are much diluted. Sulphuric and phosphoric acids do not prevent the reduction.

Acetic acid.

**Acetic Acid.**—A. Bechert(1), for the determination of acetic acid in crude vinegar, according to the method described by Biegel(2), employs carbonate instead of hydrate of baryta, which, however, has not obviated the inconvenience and inaccuracy of this process.

**Alcohol.**—J. J. Pohl has described, in a very elaborate treatise(3), a process for determining the amount of alcohol in liquids (wine, beer, brandy, &c.) It is founded, like that formerly proposed by Gröning(4), Brossard-Vidal, and others(5), upon the determination of the boiling-point of alcoholic liquids, and proceeds upon the supposition that this boiling-point is only altered to a very slight extent by the presence of moderate quantities of foreign matters, so that the change in the temperature of ebullition may be taken merely as a function of the amount of alcohol. The apparatus which Pohl employs for this purpose, is very similar to the *Ebullioscope*(6); it consists simply of a boiler, of thin metal, surrounded with a jacket, and of a thermometer, from the scale of which the percentage weights of alcohol, together with the corresponding densities, may be read off; to the thermometer, the cover of the boiler is also fastened. For such cases, where, beside the alcohol contained in a liquid, the amount of other substances present is likewise to be determined, the apparatus is furnished, in addition, with an areometer arranged and graduated expressly for these experiments. For the details of the process, and for the tables drawn up by Pohl, we must refer to the original treatise. The groundwork of these tables is stated at page 300.

**Sugar.**—Maumené(7) takes advantage of the behaviour of bichloride of tin with sugar, for the detection of that substance and of its congeners. All kinds of sugar, as also starch and woody-fibre (hemp, linen, cotton, paper), when treated with bichloride of tin (also with protochloride of mercury or terechloride of antimony), are converted, according to Maumené, into a brown substance resembling caramel, partly soluble in water; the conversion takes place slowly when the aqueous solution evaporates spontaneously, but rapidly on heating. By means of strips of woollen-merino, which

(1) Arch. Pharm. [2] LXI, 158.

(2) Annual Report for 1847 and 1848, II, 245.

(3) Denkschriften d. Mathem.-Naturwissensch. Classe d. Wien. Acad. Bd. II.

(4) Edinb. Philos. Journ. VII, 214.

(5) Compare Annual Report for 1847 and 1848, II, 13.

(6) Annual Report for 1849, III, 282.

(7) Compt. Rend. XXX, 314, 447; J. Pharm. [3] XVII, 368; Instit. 1850, 92, 122.



Sugar.

have been immersed for three or four minutes in a solution of 1 part of ordinary bichloride of tin in 2 parts of water, and dried, the sugar may be easily detected in any liquid—diabetic urine, for example—by moistening the prepared strips with a few drops of the liquid, and holding them for some instants over a red-hot coal, when a black spot immediately makes its appearance. This reaction is so delicate, that a liquid which contains in 100 cub. cents. water only 10 drops of diabetic urine, still imparts a dark brown colour to a woollen rag prepared with bichloride of tin. No coloration is produced by ordinary urine, urea, or uric acid.

Soubeiran(1) describes the process, and furnishes the needful data for detecting and estimating, by means of the saccharimeter(2), the prejudicial adulteration of syrups for medicinal use with starch-sugar. One vol. of ordinary syrup, in which the areometer stands at  $35^{\circ}$ , when diluted with 9 vols. of water, and placed, at a temperature of  $15^{\circ}$ , in a tube of 20 centimetres in length, shows a deflection of  $52^{\circ}$  to the right; when changed by heating with 2 vols. of pure hydrochloric acid, and placed in a tube of 22 centimetres, it causes a deviation of  $21^{\circ}3$  to the left. Starch-sugar, on the other hand, preserves unchanged its power of deflecting towards the right, even after treatment with the acid. On this principle, Soubeiran has calculated a table, by which, supposing only cane-sugar and starch-sugar to be contained in the syrup, the amount of each may be ascertained by the deviation of the plane of polarization before and after the action of the acid. The presence of dextrin does not diminish the accuracy of this method, since the deflective power is not affected by the acid.—The process, however, is less certain in the case of acid syrups, part of the cane-sugar of which has always suffered conversion into grape-sugar; the presence of sugar of fruits has the same effect.—The adulteration of mucilage with starch-paste may be detected by the well-known reaction of potassa at the boiling-point, when the starch becomes black; they are both precipitated by alcohol.—Lastly, Soubeiran gives, in two more tables, the deviations exhibited in the saccharimeter by specimens of mucilage containing different quantities of gum-arabic, both in their original state, and after the precipitation of the gum with acetate of lead and alcohol. In these tables he starts from the fact that 1 part by weight of gum-arabic, dissolved in 9 parts of water, deflects the plane of polarization  $28^{\circ}$  towards the left; and that a mucilage which, at the boiling-point, shows  $29^{\circ}$ , and has a density  $=1.321$ , consists of 1 vol. of gum, 1 vol. of water, and 6 vols. of sugar-syrup.

Mulder(3) has tested the method of Trommer and Barreswil for the determination of grape-sugar (as it was recently described

(1) J. Pharm. [3] XVIII, 328.

(2) Annual Report for 1849, III, 84.

(3) Scheik. Onderzoek. V, 7. Stuk, 385.

by Schwarz and Fehling [Annual Report for 1849, III, p. 419], as to its applicability for determining grape-sugar in the presence of cane-sugar. He has convinced himself that the red oxide, precipitated by boiling the alkaline solution of protoxide of copper with sugar, has really the composition of the suboxide,  $\text{Cu}_2\text{O}$ . Mulder prefers the weighing of the precipitated suboxide (previously converted into protoxide by roasting) to the employment of standard solutions. The test-liquid is best prepared from acetate of copper, tartaric acid (or bitartrate of potassa) and potassa. It must still be blue and strongly alkaline after the reduction by the sugar, so that no farther precipitate can be obtained by adding more potassa, and again heating. The temperature at which the reduction of the oxide of copper by fruit- or grape-sugar takes place is about  $60^\circ$ , wherefore the liquid to which the test is applied should be maintained for an hour at this temperature. All modes of testing which involve the application of a higher temperature must be avoided when grape- or cane-sugar is to be estimated in the presence of cane-sugar, since the latter also precipitates the suboxide of copper at temperatures above  $70^\circ$  or  $80^\circ$ . Mulder finds, in accordance with Fehling's observation, that 1 equiv. of grape-sugar ( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ) only abstracts 5 equivs. of oxygen from 10 equivs. of protoxide of copper; 1 part of the protoxide (obtained by roasting the precipitated suboxide) represents, therefore, 0.552 part of grape-sugar.

Roser(1) found, when endeavouring to estimate the amount of sugar produced by the digestion of phloridzin with acids (see p. 368), that the method proposed by Krockner(2) (determination of the carbonic acid evolved during fermentation) did not give concordant results. When an alkaline solution of protoxide of copper is employed, the estimation of the sugar is effected with certainty only when the test-liquid has been graduated with pure grape-sugar (not with cane-sugar), since the complete conversion of cane- into grape-sugar by acids is effected, as Fehling(3) has already shown, with difficulty(4).

Lassaigne(5) has observed that cane-sugar which has been exposed for some time to a high temperature, until it has acquired a more or less intense amber-yellow colour—as, for example, in barley-sugar—reduces the alkaline solution of protoxide of copper as easily as grape-sugar. He remarks that this may lead to a false conclusion respecting the presence of the latter substance when the copper-test is employed.

(1) Loc. cit. p. 368.

(2) Ann. Ch. Pharm. LVII 212.

(3) Ann. Ch. Pharm. LXXII, 108.

(4) The test-solution is best graduated with milk-sugar.

(5) J. Chim. Méd. [3] VI, 373; Chem. Gaz. 1850, 442; Phil. Mag. [3] XXXVII, 314.

**Quinine.**

**Quinine.**—As a characteristic reaction for quinine, Vogel, Jun.(1) makes use of the behaviour of this base with chlorine-water and ferrocyanide of potassium. When a solution of sulphate of quinine is mixed with chlorine-water (or with a solution of chloride of lime mixed with hydrochloric acid), and then with an excess of a concentrated solution of ferrocyanide of potassium, a dark red colour is immediately produced, which lasts for some hours, and then changes to a green... If, instead of the ferrocyanide, caustic potassa be added, the solution assumes a sulphur-yellow colour, and with ammonia, as Brandes previously observed, an emerald-green. The same appearance is not exhibited by cinchonine.—Wollweber(2) again mentions the detection of cinchonine in quinine by means of ether and ammonia.

**Cinchona Barks.**—Rabourdin(3) has published a process for testing cinchona barks as to the amount of organic bases which they contain; it is founded upon the property possessed by chloroform of withdrawing these bases from an aqueous solution.—The powdered bark (40 grms. of grey, or 20 grms. of yellow bark) is exhausted with water containing hydrochloric acid (20 grms. of acid in 1 kilogram. of water) in a percolator; the solution is mixed with 5 or 6 grms. of caustic potassa, and 15 grms. of chloroform, and shaken for some instants. After standing for half-an-hour, all the chloroform charged with the organic bases has separated; after decanting the supernatant liquid, the chloroform is repeatedly washed with water, and evaporated in a porcelain dish upon the water-bath. The residue is treated with water containing hydrochloric acid, which dissolves the bases, together with a part of the cinchona-red; to the filtrate, ammonia, diluted with 20 parts of water, is added, drop by drop, till a white precipitate appears, which does not redissolve on stirring. In this way the cinchona-red is first precipitated in red flakes; from the colourless liquid filtered therefrom, the organic bases are then precipitated by excess of ammonia.

A. Marggraf (4) stirs up 500 grns. of finely-powdered and dried cinchona bark with a mixture (still hot) of 400 grns. of concentrated sulphuric acid, and 100 grns. of water, when he obtains a pulverulent black mass; this is then triturated with an equal bulk of water, afterwards washed with water, and the bases precipitated from the solution with crystallized carbonate of soda. They are once more dissolved in acidulated water, and reprecipitated with ammonia.

**Opium.**—De Vry(5) has somewhat modified the opium-test pro-

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(1) Ann. Ch. Pharm. [XXIII, 221; J. Pharm. [3] XVIII, 36.

(2) Arch. Pharm. [2] LXIII, 6.

(3) Compt. Rend. XXXI, 782; J. Pharm. [3] XIX, 11; Instit. 1850, 395.

(4) Zeitschr. f. Pharm. 1850, 81.

(5) J. Pharm. [3] XVII, 439.

posed by Guillermond(1) in order to obtain the morphine free from narcotine. He heats the mixture of the two bases (obtained by precipitation from the spirituous solution) with a dilute aqueous solution of sulphate of copper, when the narcotine remains undissolved, whilst the morphine passes into solution as sulphate, a basic sulphate of copper being precipitated. The copper is removed from the filtrate by sulphuretted hydrogen, and the morphine then precipitated by ammonia, which separates it in a nearly colourless state. —G. Reich(2) has also described a method employed by him for ascertaining the quantity of morphine in opium.

Opium.

L. Thompson(3) describes as a mode of detecting strychnine, the employment, long since proposed by Otto, of chromate of potassa and concentrated sulphuric acid, which produces a fine purple-violet, and afterwards a yellow colour. A. W. Brieger(4) has shown that this reaction loses in delicacy, or is entirely veiled, when the strychnine is mixed with other organic substances, especially morphine, quinine, and above all, sugar, whilst santonine and starch do not conceal the reaction.

**Daturine.**—R. Allan(5) has found daturine in the urine of several persons poisoned with an infusion of *Datura Stramonium*. He succeeded in detecting it by the method described by Henry(6), of precipitating with tannic acid, decomposing the precipitate with lime, and extracting with alcohol. By evaporating the solution, Allan obtained crystals of the base, which was precipitated lemon-yellow by terchloride of gold, Isabella-coloured by bichloride of platinum, kermes-brown by tincture of iodine, and white by tannic acid.

**Indigo.**—Bolley(7) describes the following method of testing indigo. 1 grm. of finely-powdered indigo is well stirred with about 10 grms. of fuming sulphuric acid; the mixture is then heated to boiling in a two-pound evaporating-dish with water and 50 grms. of strong hydrochloric acid, the water being replaced from time to time, as it evaporates. To the boiling mixture is now added, from a graduated burette, a solution of chromate of potassa of known strength (0.25 grm. dissolved in 100 cub. cents. of water) until the liquid has lost the last trace of greenish-brown colour, and has become red-brown, a point which will be easily recognized after a little practice. The quantity of the solution of chlorate of potassa employed is the criterion of the value of the indigo.

**Test for the so-called Protein-compounds.**—Millon(8) has recently described the preparation of the mercury-solution which serves as a reagent for the so-called protein-compounds(9). Metallic mercury

(1) Annual Report for 1849, III, 422.

(2) Arch. Pharm. [2] LXI, 143.

(3) Pharm. J. Trans. IX, 24; J. Pharm. [3] XVII, 276.

(4) Jahrb. Pr. Pharm. XX, 87.

(5) Ann. Ch. Pharm. LXXIV, 223.

(6) J. Pharm., May, 1835, 213.

(7) Ann. Ch. Pharm. LXXV, 242; Chem. Gaz. 1850, 443.

(8) Ann. Ch. Phys. [3] XXIX, 507.

(9) Annual Report for 1849, III, 423.

Test for  
the so-  
called pro-  
tein-com-  
pounds.

is treated with an equal weight of nitric acid (with  $4\frac{1}{2}$  equivs. of water), gently heated when the reaction slackens, until the metal is completely dissolved, when the solution is mixed with twice its volume of water. After some hours, the liquid portion is decanted from the crystals of nitrate and nitrite which are formed. The solution owes its property of colouring the protein-compounds red solely to the presence of nitrous acid, which acts in the most characteristic manner when dissolved in a mixture of salts of the protoxide and suboxide.

**Blood.**—Gorup-Besanez(1) describes the experiments performed by himself upon the different methods of analyzing blood, the chief results of which were communicated in the Annual Report for 1849, III, p. 424.

Lassaigne(2) was able to recognize, by their behaviour, blood-stains which had soaked into a clay floor (*pavé tendre en grès*), even after they had been exposed for a month to air and moisture.

For the method of Verdeil and Dollfus for the analysis of blood, see p. 382.

**Milk.**—Zenneck(3) describes, under the name of *hydrogalactometer*, an arrangement for determining the volume of water which has been mixed with normal milk. The milk is coagulated by two drops of hydrochloric acid, and the volume of the whey, filtered through flannel, compared with that furnished by the same quantity of normal milk.

**Urine.**—Cottereau(4) describes the process adopted by him in the analysis of urine.—For Boussingault's method of estimating the ammonia in urine, see p. 403.

**Fœtal Evacuations. Cerebral Substance.**—Fresenius(5) has described the behaviour of fœtal evacuations (*meconium*) when dried upon linen, with a view to their detection and identification in judicial cases; Orfila(6) has also studied the comportment of brain, and of several other animal substances. Lassaigne(7) states that, by the careful carbonization of spots of cerebral substance upon linen, a coal is obtained, which has a distinctly acid reaction, and yields phosphoric acid to water.

**Apparatus.**—Delffs(8) has described a new simplified gasometer.—Kemp(9) describes an apparatus whereby the heat produced

(1) J. Pr. Chem. L, 346.

(2) J. Chim. Méd. [3] VI, 209.

(3) Jahrb. Pr. Pharm. XX, 65.

(4) J. Chim. Méd. [3] VI, 625.

(5) Ann. Ch. Pharm. LXXXV, 116.

(6) J. Pharm. [3] XVIII, 186.

(7) J. Pharm. [3] XVIII, 247; J. Chim. Méd. [3] VI, 564, 646.

(8) Pogg. Ann. LXXXIX, 429.

(9) Chem. Gaz. 1850 184; Phil. Mag. [3] XXXVI, 483; Instit. 1850, 231; Westly's improvements thereupon, Chem. Gaz. 1850, 239.

by a gas-flame is rendered constant.—Apparatus for the application of coal-gas for organic analysis and other chemical operations, have been described by O. B. Kühn(1) and L. S. Beale(2).—Fresenius(3) describes an apparatus for evaporation, desiccation, and the preparation of distilled water; Dublanc(4), an arrangement for hot filtration, especially of fatty substances.—Mohr(5) has made mention of a convenient stand for retorts, flasks, and porcelain dishes.

Appara-  
tus.

**Sea-water.**—Bibra(6) examined sea-water collected at 12 A.M. (unless specially indicated, about 12 feet under the level) A, in the port of Callao, 12° 5' S. Lat., 77° 14' W. Long. (from Greenwich), March 14, 1850; B in the port of Tocopilla (Algodon Bay), 22° 6' S. Lat. 70° 16' W. Long., February 21; C in the Dead Sea, about 240 feet deep, 25° 11' S. Lat., 93° 24' W. Long., March 27; D, at the same spot, 10 or 12 feet deep; E, in the neighbourhood of Cape Horn, 56° 32' S. Lat., 68° 47' W. Long., April 18; F, in the Atlantic Ocean, 23° 45' S. Lat., 29° 27' W. Long., May 12; G, in the same, 0° 47' S. Lat., 33° 20' W. Long., May 22; H, in the same, 20° 54' N. Lat., 40° 44' W. Long., June 4; I, in the same, 41° 18' N. Lat., 36° 28' W. Long., June 18; K, in the North Sea, 51° 9' N. Lat., 3° 8' E. Long., July 5. In 100 parts of water were found:

|                             | A      | B      | C.     | D.     | E.     | F.     | G.     | H.     | I.     | K.     |
|-----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Spec. grav.                 | ?      | 1·0278 | 1·0264 | 1·0260 | ?      | 1·0244 | 1·0275 | ?      | 1·0287 | 1·0264 |
| Chloride of sodium          | 2·4825 | 2·8391 | 2·5885 | 2·5887 | 2·6333 | 2·7558 | 2·7892 | 2·6424 | 2·9544 | 2·5513 |
| Bromide of sodium           | 0·0402 | 0·0441 | 0·0307 | 0·0401 | 0·0420 | 0·0326 | 0·0520 | 0·0400 | 0·0500 | 0·0373 |
| Sulphate of potassa         | 0·1409 | 0·1599 | 0·1418 | 0·1359 | 0·1327 | 0·1715 | 0·1810 | 0·1625 | 0·1499 | 0·1529 |
| "    lime                   | 0·1488 | 0·1449 | 0·1622 | 0·1622 | 0·1802 | 0·2046 | 0·1557 | 0·1597 | 0·1897 | 0·1622 |
| "    magnesia               | 0·0947 | 0·1041 | 0·1117 | 0·1104 | 0·1079 | 0·0614 | 0·0584 | 0·0678 | 0·1066 | 0·0706 |
| Chloride of magnesium       | 0·3681 | 0·3852 | 0·4884 | 0·4345 | 0·3802 | 0·0326 | 0·3332 | 0·4022 | 0·3916 | 0·4641 |
| Total of fixed constituents | 3·2752 | 3·6773 | 3·5233 | 3·4708 | 3·4763 | 3·2585 | 3·5695 | 3·4746 | 3·8422 | 3·4383 |

In most of the residues obtained on evaporation and ignition, Bibra found traces of phosphoric acid. A similar result was obtained by Forchhammer(7) in sea-water collected in the neighbourhood of Copenhagen. In this water, which contains from 2 to 2½ per cent of salts, fluoride of calcium(8), was found to be present. Forchhammer estimates the amount of this substance in 100 lbs. of water at less than ½ grain. This water contains, moreover, manganese, ammonia, baryta, or strontia, together with iron and silica which are present in comparatively larger quantities. Fluoride of

(1) Ann. Ch. Pharm. LXXIV, 115.

(3) J. Pr. Chem. L, 130.

(5) Arch. Pharm. [2] LXIII, 265.

(7) Proceedings of the Royal Society of Edinburgh, II, No. 38, 303.

(8) Annual Report for 1849, III, 425.

(2) Pharm. J. Trans. X, 9.

(4) J. Pharm. [3] XVIII, 203.

(6) Ann. Ch. Pharm. LXXVII, 90.

**Well- and river-water.** calcium was also found in corals.—Respecting the presence of phosphoric acid in sea-water, see also p. 179.

**Well- and River-Water.**—Blondeau(1) has published some observations on the alteration and deterioration of well-water by the absorption of inorganic and organic substances. Water, containing in 1 litre from 0.1 to 0.5 grm. of the commonly occurring inorganic substances (silica, alumina, carbonate of lime, carbonate of magnesia, phosphate of lime, phosphate of magnesia, sulphate of alumina-potassa, chloride of calcium, chloride of magnesium, chloride of sodium, nitrates) may be used, he says, for all domestic purposes, provided large quantities of animal substances are absent. Water containing in 1 litre 1 grm. of the above-named substances, is still suitable for drinking; water containing in 1 litre 0.1 grm. of lime or magnesia can no longer be used for boiling leguminous grains, or bleaching linen. Water which, in addition to the above amount of lime or magnesia, contains as much as 0.1 grm. of organic matter, is inapplicable for any domestic use. Blondeau attributes the deleterious effect of many waters much more to the presence of animal matter than to magnesia. He states that the well-water of Rhodéz contains 5 times the quantity of magnesia, which is present in the water of the Isère valley, examined by Grange(2), and yet goitre and cretinism are utterly unknown in this first-named place (see p. 425). The earthy taste of many waters is due to the presence of alumina held in solution by carbonic acid.—R. A. Smith(3) has made some observations on the fact that water filtering through thick layers of earth may lose those substances which it has taken up at the surface.

**In Germany and Switzerland.**—Fresenius(4) has examined the water of the Kochbrunnen at *Wiesbaden* (A; temperature 68°). The gas disengaged from the Kochbrunnen he found to consist of from 16.8 to 20.2 per cent of carbonic acid, together with nitrogen and a trace of oxygen. The composition of the deposit of this well, see p. 424.—Buchner, Jun.(5) has investigated the brine, called *Edelsoole*, at *Reichenhall* in Upper Bavaria (B); it contains free carbonic acid, which was not, however, accurately determined.—Fellenberg(6) analyzed the sulphur-water of the *Gurnigelbad* in the canton of Berne. He examined both the *Stockquelle* (C; temperature 7°; the

(1) Compt. Rend. XXX, 481.

(2) Annual Report for 1847 and 1848, II, 253, 466; for Grange's opinion regarding the deleterious effects of magnesia in drinking water, we refer to Annual Report for 1842, III, 558.

(3) Instit. 1850, 336.

(4) Unters. d. Mineralwasser d. Herzogthums Nassau, I, Wiesbaden, 1850; this paper contains also a synopsis of the former analyses; for Lade's, Figuier's and Mialhe's analyses, we refer to Annual Report for 1847 and 1848, II, 260.

(5) Repert. Pharm. [3] VI, 30.

(6) Untersuchung d. Schwefelwasser d. Gurnigelbades, Bern, 1849.

composition of the deposit, see p. 424), and the Schwarzbrünnliquelle (D; temperature 80.5) The following table gives the amount of fixed constituents, expressed in grms. and of gases, expressed in cub. cents., and calculated for the temperature of the springs, in 10,000 grms. of water.

Well- and river-water in Germany and Switzerland.

| Spec. grav. . . . .                   | A.<br>1.00666 | B.<br>1.18145 | C.<br>1.00182 | D.<br>1.00192 |
|---------------------------------------|---------------|---------------|---------------|---------------|
| Chloride of sodium . . . . .          | 68.3565       | 2243.63       | 0.041         | 0.053         |
| „ potassium . . . . .                 | 1.4580        | —             | —             | —             |
| „ lithium . . . . .                   | 0.0018        | —             | —             | —             |
| „ ammonium . . . . .                  | 0.1672        | 0.25          | —             | —             |
| „ calcium . . . . .                   | 4.7099        | —             | —             | —             |
| „ magnesium . . . . .                 | 2.0391        | 18.02         | —             | —             |
| Iodide of magnesium . . . . .         | trace         | —             | —             | —             |
| Bromide of magnesium . . . . .        | 0.0355        | 0.30          | —             | —             |
| Sulphate of lime . . . . .            | 0.9022        | 41.65         | 15.833        | 13.039        |
| „ potassa . . . . .                   | —             | 6.12          | 0.090         | 0.846         |
| „ soda . . . . .                      | —             | 20.00         | 0.322         | 0.512         |
| „ magnesia . . . . .                  | —             | —             | 1.033         | 0.550         |
| „ strontia . . . . .                  | —             | —             | 0.073         | 0.138         |
| Hyposulphite of potassa . . . . .     | —             | —             | 0.045         | 0.084         |
| Sulphide of calcium . . . . .         | —             | —             | —             | 0.045         |
| „ magnesium . . . . .                 | —             | —             | —             | 0.012         |
| Carbonate of lime . . . . .           | 4.1804        | 0.10          | 1.668         | 1.903         |
| „ magnesia . . . . .                  | 0.1039        | trace         | 0.111         | 1.007         |
| „ protoxide of iron . . . . .         | 0.0565        | —             | 0.018         | 0.037         |
| „ „ manganese . . . . .               | 0.0059        | —             | —             | —             |
| „ baryta . . . . .                    | trace         | —             | —             | —             |
| „ strontia . . . . .                  | trace         | —             | —             | —             |
| „ protoxide of copper . . . . .       | trace         | —             | —             | —             |
| Phosphate of lime . . . . .           | 0.0039        | —             | 0.029         | 0.031         |
| Arseniate of lime . . . . .           | 0.0015        | —             | —             | —             |
| Silicate of alumina . . . . .         | 0.0051        | —             | —             | —             |
| Silica . . . . .                      | 0.5992        | 0.11          | 0.127         | 0.194         |
| Alumina . . . . .                     | —             | 0.08          | —             | —             |
| Sesquioxide of iron . . . . .         | —             | —             | —             | —             |
| Organic substances . . . . .          | trace         | —             | —             | —             |
| Total of fixed constituents . . . . . | 82.6266       | 2330.26       | 19.390        | 18.452        |
| Free carbonic acid . . . . .          | 5229.0        | ?             | 1853.11       | 4011.36       |
| Nitrogen . . . . .                    | 32.2          | —             | 188.43        | 240.74        |
| Hydrosulphuric acid . . . . .         | —             | —             | 13.26         | 180.94        |

Fresenius(1) has examined A the lighter part of the muddy deposit which is formed in one of the drains of the Kochbrunnen at Wiesbaden, B the sinter deposited in the basin of the spring, C another sinter taken in the dry state from one of the drains. He found(2) that the arsenic in this sinter is present in the form of arsenic acid, and not as arsenious acid.—Blum and Leddin found in 1000(3)

(1) Loc. cit. p. 422.

(2) Ibid.; also Ann. Ch. Pharm. LXXV, 172.

(3) Ann. Ch. Pharm. LXXIII, 217.



Well- and  
river-  
water in  
Germany  
and Switz-  
erland.

parts of a dark ferruginous specimen of Sprudelstein from *Carlsbad* 2.72 of arsenic.—Fellenberg(1) analyzed the mud deposited by the Stockquelle of the *Gurnigelsbad* (see p. 423) D.

|                                               | A.      | B.       | C.       | D.     |
|-----------------------------------------------|---------|----------|----------|--------|
| Carbonate of lime . . . . .                   | 13.663  | 90.7364  | 94.3390  | 13.67  |
| " " magnesia . . . . .                        | trace   | 0.4965   | 0.6760   | 1.78   |
| Sulphate of lime . . . . .                    | trace   | 0.0134   | 0.1860   | 2.77   |
| " " baryta . . . . .                          | 0.164   | trace    | 0.0518   | —      |
| " " strontia . . . . .                        |         |          |          |        |
| Sesquioxide of manganese . . . . .            | —       | —        | —        | 2.27   |
| " " iron . . . . .                            | 61.103  | 4.8886   | 2.2225   |        |
| Carbonate of protoxide of manganese . . . . . | trace   | trace    | 0.2647   | —      |
| Protoxide of copper . . . . .                 | trace   | trace    | trace    | —      |
| Alumina . . . . .                             | trace   | trace    | trace    | 14.47* |
| Arsenic acid . . . . .                        | 1.736   | 0.1210   | 0.0495   | —      |
| Phosphoric acid . . . . .                     | 0.075   | trace    | trace    | —      |
| Silica . . . . .                              | 10.447  | 1.1712   | 0.4530   | 0.36   |
| Silicate of lime . . . . .                    | 3.346   | —        | —        | —      |
| Organic substances . . . . .                  | trace   | trace    | trace    | —      |
| Soluble salts . . . . .                       | trace   | trace    | trace    | —      |
| Sand and ferruginous clay . . . . .           | —       | —        | —        | 56.96  |
| Water, substances not determined and loss     | 9.466   | 2.5775   | 1.7575   | 7.72†  |
|                                               | 100.000 | 100.0000 | 100.0000 | 100.00 |

\* With phosphate of lime.

† Together with free sulphur.

The mineral waters of *Jahorowitz* in Moravia have been examined(2); the *Henriettenquelle*, by Ehrmann (A); and the so-called *Lungenwasser*, by Steigenberger (B).

| A; in 1 Mass.                                 | Grs.        | B; in 1 Vienna quart.<br>(Viertelmass). | Grs.  |
|-----------------------------------------------|-------------|-----------------------------------------|-------|
| Chloride of sodium . . . . .                  | 18.625      | Free carbonic acid . . . . .            | 3.006 |
| Bicarbonate of soda . . . . .                 | 24.943      | Chloride of sodium . . . . .            | 2.625 |
| " " lime . . . . .                            | 1.966       | Sulphate of soda . . . . .              | 4.375 |
| Silica . . . . .                              | 1.400       | " " lime . . . . .                      | 0.750 |
| Iodide of magnesium . . . . .                 | 1.402       | Carbonate of magnesia . . . . .         | 0.500 |
| Bicarbonate of protoxide of iron . . . . .    | 1.000       | Alumina and iron . . . . .              | 0.125 |
| Bromide of magnesium . . . . .                | 0.096       | Silica . . . . .                        | 0.500 |
| Carbonate of protoxide of manganese . . . . . | trace       |                                         |       |
| Sulphates and phosphates . . . . .            | trace       |                                         |       |
| Free carbonic acid . . . . .                  | 20 cub. in. |                                         |       |

**In Galicia and in Bukowina.**—Torosiewicz(3) has made some observations on the mineral waters of Galicia and Bukowina.

**In England.**—Beesley(4) has examined the water of *Overthorp*, near *Banbury* (A), which, in contact with the air, deposits basic sulphate of alumina. He has analyzed(5), moreover, the mineral water

(1) Loc. cit. p. 423.

(2) From Zeitschr. f. Nat.- und Heilk. in Ungarn, 1850, No. 2 in Arch. Pharm. [2] LXIV, 293.

(3) Repert. Pharm. [3] V, 169.

(4) Pharm. J. Trans. IX, 452.

(5) Pharm. J. Trans. X, 293.

of *Astrop Wells* (Northampton) (B), and of *Sutton Bog* (C). 10,000 water contains: Well- and river-water in England.

| Spec. grav.                       | A.<br>? | B.<br>? | C.<br>1·0023 |
|-----------------------------------|---------|---------|--------------|
| Sulphate of potassa . . .         | 0·1551  | 0·1243  | 0·1542       |
| „ soda . . .                      | 1·6548  | 1·5247  | 14·9336      |
| „ lime . . .                      | 6·3077  | 6·122   | —            |
| „ magnesia . . .                  | 2·4343  | 0·5636  | —            |
| „ alumina (neutr.) . . .          | 1·9669  | —       | —            |
| „ „ (basic) . . .                 | 0·1390  | —       | —            |
| Carbonate of lime . . .           | —       | 3·7458  | 0·8949       |
| „ magnesia . . .                  | —       | 0·1037  | 0·4222       |
| „ protoxide of iron . . .         | —       | 0·0486  | —            |
| „ soda . . .                      | —       | —       | 2·3530       |
| Chloride of sodium . . .          | —       | —       | 8·1650       |
| „ magnesium . . .                 | 0·7480  | 0·2846  | —            |
| Iodide of sodium . . .            | —       | —       | 0·0071       |
| Sesquioxide of iron . . .         | —       | —       | 0·0107       |
| Alumina . . .                     | —       | 0·0117  | 0·0107       |
| Silica . . .                      | 0·3000  | 0·1528  | 0·0804       |
| Total of fixed constituents . . . | 13·7058 | 7·1720  | 27·0211      |

J. Mitchell(1) has examined the water (A) of an artesian well (215 feet deep) at *Ratcliffe* (spec. grav. 1·00089); J. S. Muspratt(2), the water of a spring (B), at *Orrell*, near *Wigan*, which is remarkable for the quantity of carbonate of soda it contains. Grains contained in 1 gall. :

|                                   | A.      | B.    |
|-----------------------------------|---------|-------|
| Carbonate of lime . . .           | 7·2238  | 5·17  |
| „ magnesia . . .                  | 2·1741  | 2·99  |
| „ protoxide of iron . . .         | 0·1941  | —     |
| „ soda . . .                      | 6·2802  | 23·86 |
| Sulphate of potassa . . .         | 1·2621  | —     |
| „ soda . . .                      | 6·4997  | trace |
| Sesquioxide of iron . . .         | —       | trace |
| Chloride of sodium . . .          | 10·0575 | 9·94  |
| Silica . . .                      | 1·1461  | 2·04  |
| Organic substances . . .          | 0·5740  | —     |
| Total of fixed constituents . . . | 35·4116 | 44·00 |

**In France.**—Maumené(3) has examined several waters from the neighbourhood of *Rheims*. He found both well- and river-water free from magnesia, although goitre occurred frequently at *Rheims*, when only well-water was in use (see p. 422). The gas which was evolved from the river *Vesle*, near *Rheims*, greatly polluted by drainage, contained (A, collected June 18, 1849, at 18°·8; B, collected January 26, 1850, at 9°·9):

(1) Chem. Soc. Qu. J. III, 1.

(2) Pharm. J. Trans. X, 59.

(3) Compt. Rend. XXXI, 270; without the numeric results of the analyses, J. Pharm. [3] XVIII, 244; Instit. 1850, 282.

| Well and river-water in France. | O   | N   | H    | C <sub>2</sub> H <sub>4</sub> | C <sub>3</sub> H <sub>4</sub> | CO   | CO <sub>2</sub> | Total. |
|---------------------------------|-----|-----|------|-------------------------------|-------------------------------|------|-----------------|--------|
| A                               | 0.3 | 2.8 | 10.0 | 48.4                          | 6.3                           | 14.2 | 18.0            | 100.0  |
| B                               | 0.4 | 1.9 | 18.3 | 42.5                          | 6.6                           | 21.8 | 8.5             | 100.0  |

In his opinion, in water containing carbonate of lime, alumina is never present in the form of sulphate of alumina-potassa; and alumina is not kept in solution in any kind of water by carbonic acid (see p. 422).—Mauméné quotes the analysis of the water from 18 different places (in most cases, from special wells), for which we refer to the original paper. We only give the results obtained in the analysis of the water of the river *Vesle* (A, collected January 23, 1849, near the Chateau-d'Eau; B, collected June 18, 1849, in the same place; C, collected the same day near Saint-Brice), and of the river *Suippe* (D).—Kosmann(1) has examined the mineral water (E) of *Niederbronn* (Dep. of Lower Rhine); Poumarède(2), the mineral water (F) of *Vilaine-Saint-Aubin* (Dep. des Loiret). The table gives the amount of solid constituents in grms. of gases in litres, in 1 litre of water:

|                                           | A.      | B.      | C.      | D.      | E.      | F.     |
|-------------------------------------------|---------|---------|---------|---------|---------|--------|
| Carbonate of lime . . .                   | 0.16548 | 0.16433 | 0.17470 | 0.15719 | 0.17912 | 0.051* |
| „ protoxide of iron . .                   | —       | —       | —       | —       | 0.01035 | —      |
| „ magnesia . . .                          | —       | —       | —       | —       | 0.00653 | trace* |
| „ potassa . . .                           | —       | —       | —       | —       | —       | trace* |
| „ soda . . .                              | —       | —       | —       | —       | —       | 0.053* |
| Sulphate of potassa . .                   | 0.00268 | 0.00270 | 0.01365 | 0.00371 | —       | —      |
| „ lime . . .                              | —       | —       | —       | —       | 0.07417 | —      |
| Chloride of potassium .                   | 0.00220 | 0.00297 | 0.00329 | 0.00381 | 0.13198 | —      |
| „ sodium . . .                            | 0.00562 | 0.00590 | 0.00947 | 0.00589 | 3.08857 | 0.041  |
| „ calcium . . .                           | —       | —       | —       | —       | 0.79445 | —      |
| „ magnesium . . .                         | —       | —       | —       | —       | 0.31171 | —      |
| „ lithium . . .                           | —       | —       | —       | —       | 0.00433 | —      |
| „ ammonium . . .                          | —       | —       | —       | —       | trace   | —      |
| Bromide of sodium . .                     | —       | —       | —       | —       | 0.01072 | —      |
| Iodide of sodium . .                      | —       | —       | —       | —       | trace   | —      |
| Phosphate of soda . .                     | —       | —       | —       | —       | —       | 0.011  |
| Silica . . .                              | 0.00182 | 0.00178 | 0.00160 | 0.00248 | 0.00100 | 0.025  |
| Alumina . . .                             | 0.00112 | 0.00119 | 0.00140 | 0.00197 | trace   | 0.028  |
| Sesquioxide of iron . .                   | 0.00364 | 0.00425 | 0.00518 | 0.00530 | —       | trace  |
| Silicate of sesquioxide of iron           | —       | —       | —       | —       | 0.01502 | —      |
| Arsenic . . .                             | —       | —       | —       | —       | trace   | trace  |
| Humates, crenates and apocrenates . . .   | 0.00737 | 0.00819 | 0.00719 | 0.01066 | —       | —      |
| Organic substance containing nitrogen . . | —       | —       | —       | —       | —       | 0.017  |
| Nitrate of soda . . .                     | —       | —       | 0.00180 | —       | —       | —      |
| Total . . .                               | 0.19043 | 0.19131 | 0.21828 | 0.19101 | 4.62795 | 0.226  |
| Oxygen . . .                              | 0.01868 | 0.01562 | 0.01903 | 0.01762 | —       | —      |
| Nitrogen . . .                            | 0.00822 | 0.00577 | 0.00609 | 0.00771 | —       | —      |
| Carbonic acid . . .                       | 0.00415 | 0.00580 | 0.00827 | 0.00589 | —       | —      |

\* Bicarbonates.

(1) J. Pharm. [3] XVII, 43; J. Pr. Chem. L, 49 (in abstr.)

(2) Rev. Scientif. Industr. XXXVIII, 21.

Braconnot(1) found the water of the lake of *Gérarmer* in the Vosges almost free from inorganic substances.—E. Marchand(2) found bromine and iodine in the drinking-water of *Fécamp* (see p. 183). For the determination of the remainder of the constituents, we refer to the original.—Filhol(3) has endeavoured to prove that the sulphurous constituent in the water of *Bagnères-de-Luchon*, and in the other sulphur-water of the Pyrenees, exists as protosulphide of sodium, accompanied by a small quantity of sulphuretted hydrogen, arising from the decomposition of the former under the joint influence of the air, the water and the silica contained in the latter.

O. Henry(4) has examined the mineral water of *Cransac* (Dep. des Aveyron); A, source haute (Richard); B, source basse (Richard); the ochry deposit contains arsenic. The water of a mineral well in that neighbourhood, called du Fraysse(5) has been analyzed by O. Henry (C), and Poumarède (D). Blondeau(6) attributes the effect of the water of Cransac to sulphide of arsenic. The amount of (anhydrous) constituents is stated for 1000 parts:

|                                       | A.    | B.   |                       | C.    | D.    |
|---------------------------------------|-------|------|-----------------------|-------|-------|
| Sulphate of proto-sesquioxide of iron | 0.750 | 0.05 | Sulphate of magnesia  | 0.479 | 0.503 |
| " protoxide of manganese              | 0.507 | 0.28 | " lime                | 0.499 | 0.499 |
| " alumina . . . . .                   | 2.843 | 6.15 | " alumina . . . . .   | 0.368 | 0.369 |
| " lime . . . . .                      |       |      | " manganese           | 0.150 | 0.155 |
| " magnesia . . . . .                  |       |      | " iron . . . . .      | 0.045 | 0.045 |
| " soda? . . . . .                     |       |      | " soda . . . . .      | 0.240 | 0.248 |
| " alumina-ammonia . . . . .           |       |      | " potassa . . . . .   | —     | trace |
| Traces of chlorides and silicates     |       |      | Chloride of magnesium | 0.011 | 0.011 |
| Free sulphuric acid . . . . .         |       |      | Silica . . . . .      | 0.010 | 0.005 |
|                                       |       |      | Phosphates . . . . .  | —     | trace |
|                                       | 4.100 | 6.48 |                       | 1.802 | 1.835 |

**In Greece and the East.**—Landerer has made statements on some Oriental waters (for the most part only as to the general chemical characters or the qualitative composition). His statements refer to the mineral waters of Hermione(7), of the island of Zante(8), of the island of Chos(9), of Candia; to Phrygian and Syrian mineral waters, to the mineral waters of the Libanon and Antilibanon(10); to the water of the Galilean Sea, and of the thermal springs of Tiberias(11);

(1) J. Chim. Méd. [3] VI, 65.

(2) J. Pharm. [3] XVII, 356.

(3) Compt. Rend. XXX, 735; Instit. 1850, 387; Soubeiran's Report J. Pharm. [3] XVIII, 177; see Annual Report for 1849, 431.

(4) J. Pharm. [3] XVII, 161; J. Pr. Chem. L, 126. For the composition of some waters not employed medicinally, we refer to Rivot, J. Pharm. [3] XVII, 162.

(5) J. Chim. Méd. [3] VI, 314.

(6) Compt. Rend. XXXI, 313; Instit. 1850, 281.

(7) Arch. Pharm. [2] LXIV, 273. (8) Ibid. 275.

(9) J. Pharm. [3] XVIII, 417. (10) Arch. Pharm. [3] LXIII, 151.

(11) Arch. Pharm. [3] LXIII, 157.

Well- and  
river-  
water in  
North  
America.

to the water of a spring in Canaan(1); and lastly to the water of the Acheron, Cocytus and Lethe(2).

**In North America.**—C. T. Jackson(3), has examined the water of a hot spring (temp. 42°) issuing from a sandstone hill in the neighbourhood of the Great Salt Lake. He has found in 1 pint 44 grs. of fixed constituents, 1·280 carbonate of lime, 0·208 sesquioxide of iron with traces of manganese, 2·907 lime, 18·421 chlorine, 15·344 soda, 2·073 magnesia, 3·748 sulphuric acid (loss 0·019). The water contains, moreover, some free carbonic acid, the quantity of which was not determined.

The acid water of *Oak Orchard* (Alabama, New York) was examined(4) by H. Erni (A) and W. Craw (B).—T. S. Hunt(5) has analyzed the mineral water of *Caledonia*, in Canada, of the gas-spring (C), of the salt-spring (D), of the sulphur-spring (D), (which contains moreover a very small quantity of sulphuretted-hydrogen), and of the intermittent spring (F).—Composition in 1000 parts of water :

| Spec. grav.                 | A.      | B.     | C.     | D.     | E.     | F.      |
|-----------------------------|---------|--------|--------|--------|--------|---------|
|                             | 1·00482 | —      | 1·0062 | 1·0058 | 1·0037 | 1·0109  |
| Chloride of sodium . . .    | —       | 0·0363 | 6·9675 | 6·4409 | 3·8430 | 12·2500 |
| „ potassium . . .           | —       | —      | 0·0309 | 0·0296 | 0·0230 | 0·0305  |
| „ calcium . . .             | —       | —      | —      | —      | —      | 0·2871  |
| „ magnesium . . .           | —       | —      | —      | —      | —      | 1·0338  |
| Bromide of magnesium . . .  | —       | —      | —      | —      | —      | 0·0238  |
| Iodide of magnesium . . .   | —       | —      | —      | —      | —      | 0·0021  |
| Bromide of sodium . . .     | —       | —      | 0·0151 | 0·0170 | 0·0100 | —       |
| Iodide of sodium . . .      | —       | —      | 0·0005 | 0·0015 | trace  | —       |
| Sulphate of potassa . . .   | 0·1061  | 0·0822 | 0·0053 | 0·0048 | —      | —       |
| „ soda . . .                | 0·1196  | 0·0945 | —      | —      | 0·0183 | —       |
| „ lime . . .                | 1·1065  | 1·1161 | —      | —      | —      | —       |
| „ magnesia . . .            | 0·4592  | 0·5305 | —      | —      | —      | —       |
| „ protox. of iron . . .     | 0·4356  | 0·4266 | —      | —      | —      | —       |
| „ alumina (neutral) . . .   | 0·3702  | 0·5232 | —      | —      | —      | —       |
| Carb. of soda . . .         | —       | —      | 0·0486 | 0·1762 | 0·4558 | —       |
| „ lime . . .                | —       | —      | 0·1480 | 0·1175 | 0·2100 | 0·1265  |
| „ magnesia . . .            | —       | —      | 0·5262 | 0·5172 | 0·2940 | 0·8632  |
| „ protoxide of iron . . .   | —       | —      | trace  | trace  | trace  | trace   |
| „ manganese . . .           | —       | —      | trace  | trace  | —      | —       |
| Alumina . . .               | —       | —      | 0·0044 | trace  | 0·0027 | trace   |
| Silica . . .                | 0·0656  | 0·0684 | 0·0310 | 0·0425 | 0·0840 | 0·0225  |
| Chlorine . . .              | trace   | —      | —      | —      | —      | —       |
| Organic substance . . .     | trace   | —      | —      | —      | —      | —       |
| Free sulphuric acid . . .   | 2·0122  | 2·0070 | —      | —      | —      | —       |
| Free carbonic acid . . .    | —       | —      | 0·3490 | 0·2920 | 0·1410 | 0·5014  |
| Total of fixed constituents | 4·6750  | 4·6848 | 8·1265 | 7·6392 | 5·0818 | 15·1409 |

(1) Arch. Pharm. [3] LXIII, 160.

(2) Repert. Pharm. [3] VI, 352.

(3) From Proc. Bost. Soc. Nat. Hist., 1850, 224 in Sill. Am. J. [2] X, 134.

(4) Sill. Am. J. [2] IX, 449.

(5) Ibid. 266.

# TECHNICAL CHEMISTRY.

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**Metals and Alloys. Plating with Platinum.**—C. Bromeis(1) has published the following observations on plating metals with platinum. The combination of the platinum with the metallic plate by means of solder is not practicable, partly because the solder is with difficulty made to adhere at all places, and partly because it enters into the substance of the platinum.—In order to obtain a combination of platinum with silver which will stand the action of the rolls, it simply requires a perfectly metallic surface, for which purpose the treatment of the silver plate with the scraping-iron suffices.—To plate brass and copper, two methods are applicable: either to silver or gild the surface of the metal upon which the platinum is to be put, or to weld the platinum-foil and the metal together by means of spongy platinum. In the latter case the metallic plate is first cleaned with sulphuric acid and scoured with fine sand; it is then densely covered with very finely-powdered, spongy platinum, by means of a sieve, and upon this from 2 to 5 foils of platinum are laid, according to the thickness of the plating desired. The uppermost foil must project over the others and over the metal, and must be bent over the rim of the latter. The whole is finally surrounded with a thin and (to prevent adhesion) uncleaned copper sheet, solely for the purpose of keeping all impurities off the layers which are to be united; the parcel is then made red hot and passed through the rolls. The process of heating must be repeated several times during the process of rolling out; but already after the first heating the copper sheeting becomes superfluous and may be removed.

Metals  
and  
alloys.  
Plating  
with  
platinum.

Sheets plated in the above manner, resist the action of strong acids, even when the coating of platinum possesses a thickness of only  $\frac{1}{36000}$  part of an inch. By repeated ignition the coating gradually scales off; since this is mainly caused by the penetration of the base metal, such sheets as are plated on both sides, or whose substratum consists of silver, resist longer.—The plating with platinum is therefore less applicable for vessels used for ignition, than for evaporating-dishes, &c., or for galvanic apparatus, especially those of large dimensions.

Separation  
of gold  
from arse-  
nic-resi-  
dues.

**Separation of Gold from Arsenic-residues.**—According to a communication of Th. Richter(1), some experiments made by Plattner at Freiberg confirm the observations of Duflos (quoted in last year's Report, p. 442) on the separation of gold from the arsenic-residues of Reichenstein, by means of chlorine-water. Plattner—to whom the priority of this method is given—is said to have thus obtained from  $\frac{1}{10}$  to  $\frac{1}{4}$  of an ounce of gold from a hundred-weight (therefore double the quantity obtained by Duflos), by means of an apparatus fitted up like the extracting-tubs used in Augustin's method for the separation of silver.

**Volatilization of Gold and Silver during the Process of Roasting.**—Experiments made by W. Fuchs(2) on the parting of silver and copper in the moist way, have afforded him an opportunity of making an observation on the deportment of gold and silver on roasting the products which contain those metals. On exposing to a red heat (for the purpose of disintegration) *black copper*, containing arsenic and antimony, a considerable loss was sustained; also in the first period of roasting the black copper-schlich this loss was not inconsiderable; it decreased, however, gradually, and disappeared entirely when the oxydation of the schlich was completed. Black copper, roasted and exhausted by sulphuric acid, sustained by repeated roastings an appreciable loss of gold and silver, only when the mass was previously mixed with some charcoal-powder. Copper-matt showed a perfectly analogous deportment; it did not sustain a loss of the noble metals by the actual process of roasting, but only when charcoal was added after the oxydation of the metallic sulphides was effected. Fuchs concludes, that the volatilization of the gold and silver on roasting was solely effected by the agency of volatile metals, and by no means by sulphur, sulphides or metallic oxides; he says, the conclusions drawn by Malaguti and Durocher from experiments on this subject (Annual Report for 1849, III, p. 440) are certainly erroneous.—In the experiments mentioned, the proportion of gold to silver in the residues of the ignition and roasting processes remained always unchanged, however great the decrease in their total amount was.

**Extraction of Silver from its Ores.**—On subjecting that portion of these residues which was insoluble in sulphuric acid to a trial-amalgamation, Fuchs obtained an amalgam containing copper, silver and gold, which, when ignited under the bell-jar, left on the plates a spongy dendritic mass of a remarkably unequal appearance. It exhibited the colour of copper in the interior and below, and was only on the prominent parts covered with silver.

(1) J. Pr. Chem. LI, 151; Dingl. Pol. J. CXVIII, 421.

(2) Wien. Acad. Ber. October, 1850, 270.

J. Percy(1) tried the following agents for the purpose of extracting the (auriferous) silver from roasted South American ores imported into England: hyposulphite of soda, chlorine-water, with addition of chloride of sodium (or potassium), solution of bleaching-powder, and subsequent treatment with hyposulphite of soda, and lastly sesquichloride of iron. Percy found, as the general result, that sesquichloride of iron extracts *pure* silver, the other agents *auriferous*, in considerable quantities; that, however, in the most successful instance, 13·5 per cent of the contents of noble metals in the roasted ores are left in the residuc; besides, that the action of hyposulphite of soda is materially weakened when the coarsely-powdered ore is finely triturated. He suggests especially bleaching-powder and chlorine (-water) for the conversion of the silver into chloride of silver, and thinks that hyposulphite of soda may be replaced with advantage by hyposulphite of lime. Respecting the details of these experiments, we refer to the original paper.

Extraction  
of silver  
from its  
ores.

The investigation of Malaguti and Durocher (mentioned in last year's Report, p. 440), on the occurrence and extraction of silver, has now been communicated more in detail(2).

Respecting the method of extracting silver in the moist way, mentioned in the Annual Report for 1847 and 1848, II, p. 277), which is based on the solubility of chloride of silver in a solution of chloride of sodium, we have to observe, that it was not discovered by Ziervogel, who only improved it, but by Augustin(3). Experiments on this point, recently made by Patera(4), have led to a very satisfactory result.

**Removing of Silver-stains.**—In order to remove silver-stains on the skin, or the writing with solution of nitrate of silver on textile fabrics, Brieger(5) recommends to wet the stain first with tincture of iodine, and then with dilute solution of potassa, and afterwards to wash it with water. Neither the solution of iodide of potassium, nor that of cyanide of potassium, are said to equal this method in point of speedy action.

**Distillation of Mercury.**—Violette(6) recommends overheated steam for the distillation of mercury, especially of silver-amalgam, in silver smelting-houses; inasmuch as this method is less inju-

(1) Phil. Mag. [3] XXXVI, 1; Dingl. Pol. J. CXV, 281; J. Pr. Chem. L, 320.

(2) Ann. Min. [4] XVII, 3, 245, 461 (in the latter place especially on the amalgamation; see Annual Report for 1849, III, 441) Laur. and Gerh. C. R. 1851, 44 (in abstr.)

(3) An extensive description of the manipulations in the application of this method to mining and smelting products in Dingl. Pol. J. CXVI, 147, and in the work: Die Augustin'sche Silberextraction in ihrer Anwendung auf Hüttenproducte und Erze, von Aug. Grützner, Braunschweig, 1851.

(4) Wien. Acad. Ber. July, 1850, 139.

(5) Jahrb. Pr. Pharm. XX, 90.

(6) Compt. Rend. XXXI, 546; J. Pr. Chem. LI, 313.





On the amount of nitrogen in cast-iron, compare the investigations of Buchner, Sen., and R. F. Marchand, discussed p. 221. Incidentally to this investigation, Marchand analyzed the residue left, after dissolving white cast-iron in hydrochloric acid. When heated to 400°, it was converted into a white mass, whilst much fetid oil escaped: the former, fused with soda, was found to contain 76·72 per cent of silica, 17·96 of protoxide of iron, 1·96 of sesquioxide of manganese, 0·2 of alumina, 0·12 of lime, some alkali and soda.

Information on the smelting of magnetic iron-ore in Pennsylvania, in a statistical point of view, has been given by Fairbairn(1).

**Steel.**—Riepe(2) has taken out a patent in England for a method employed for some time in Germany, viz.: to refine steel in the puddling furnace. For the description of the manipulations, see the original.

**Wrought-Iron.**—In wrought-iron of Königsbrunn, which was both cold- and hot-short, Rubach(3) found: iron, 96·89 per cent; nickel, 1·53; cobalt, 0·63; carbon, 0·19. It was perfectly free from copper, arsenic, phosphorus, sulphur, and silica.

**Copper.**—Pomeroi(4) has taken out a patent for coppering objects of wrought-iron by immersing them into melted copper, and Brooman(5), for the galvanic coppering of types and stereotype-plates.

In a paper on phosphoretted copper (which has partly been noticed in last year's Report, p. 239); J. Percy(6) mentions some observations made by Capt. James on the deportment of that substance in sea-water. Of 10 different kinds of copper-sheets, which had been lying in sea-water for nine months, the phosphoretted copper was the only one which did not sustain a loss in weight; it had simply acquired a slight green coating, whilst the other samples lost as much as 3 grains per square inch.

In 2 sorts of nails for ship-sheeting, the one of which (a) was found by experience to be attacked by sea-water, whilst the other (b) had resisted even the protracted action of it, Percy found:

|       | Copper. | Zinc. | Lead. | Tin. |
|-------|---------|-------|-------|------|
| a . . | 52·73   | 41·18 | 4·72  | —    |
| b . . | 62·62   | 24·64 | 8·69  | 2·64 |

G. Reich(7) also confirms the experiments on malleable brass (Annual Report for 1849, III, 446). A specimen made of 33 parts of copper, and 25 parts of zinc (of Silesia), was, however, malleable at

(1) Chem. Gaz. 1850, 293.

(2) Dingl. Pol. J. CXVIII, 207, from Rep. of Pat. Invent. 1850, 222.

(3) Ann. Ch. Pharm. LXXIV, 360; Dingl. Pol. J. CXVII, 395; compare Annual Report for 1849, III, 437.

(4) From Lond. Journ. of Arts, Oct. 1850, 166, in Dingl. Pol. J. CXVIII, 116.

(5) From Lond. Journ. of Arts, Oct. 1850, 179, in Dingl. Pol. J. CXVIII, 118.

(6) Chem. Gaz. 1850, 1; Arch. Pharm. [2] LXIV, 180.

(7) Arch. Pharm. [2] LXI, 266.

Copper.

a red heat only; at a white heat, it became brittle (does it not melt at a really white heat?): it contained, on analysis, 58.16 per cent of copper, and 41.84 per cent of zinc. The presence of iron and lead are said to have a very injurious effect on the malleability.

Donovan(1) obtained the following result on analyzing antique bronzes found near Downris (King's County), viz.: a piece of a "cell" (a), and of a drinking-horn (b):

|   | Copper. | Tin.  | Lead. | Carbon and Sulphur. |
|---|---------|-------|-------|---------------------|
| a | 85.23   | 13.11 | 1.14  | 0.15                |
| b | 79.34   | 10.87 | 9.11  | —                   |

Salvétat(2) communicated the analyses of two bronze rings found in a Gallic-Roman grave near Dieppe, the date of which has been fixed for the second half of the fourth century: 1. outside blackish, brittle, with a greyish fracture; 2. outside lighter, less brittle, with a slightly-yellow fracture. He found in:

|    | Tin.  | Copper. | Lead. | Zinc. | Loss. |
|----|-------|---------|-------|-------|-------|
| 1. | 23.52 | 75.55   | 0.47  | 0     | 0.46  |
| 2. | 15.73 | 79.93   | 3.50  | 0     | 0.84  |

**Salts. Potashes.**—H. Wurtz(3) attempted to produce chloride of potassium and potashes from the green sand of New Jersey. He says, that he obtained the whole amount of potassa in the form of chloride of potassium, by igniting the sand with chloride of calcium, and extracting the ignited mass; the application of sulphuric acid and sulphates did not lead to a satisfactory result.

**Soda.**—According to Abich(4), the crude soda coming from the plain of the Araxes is obtained by the combustion of some particular species of *Salsola*. When ignited, it loses 2.5 to 3 per cent in weight; and when extracted with water, it leaves a residue of from 30 to 31 per cent. The aqueous solution yields, of crystallized carbonate of soda, nearly 100 per cent by weight of the crude soda used, and contains very little sulphate of soda, somewhat more caustic soda, in addition to a considerable quantity of potassa, combined partly with carbonic acid, partly with chlorine.

**Soft Soap.**—Gentile(5) found, by experiments on the large scale, that in the manufacture of soft soap part of the potashes may be replaced by the far cheaper soda. A ley containing, for 4 parts of caustic potassa, 1 part of caustic soda, produced with hemp-oil (with addition of some tallow and oleic acid) a soft soap of good quality, and at the same time a larger quantity, than one containing

(1) Chem. Gaz. 1850, 176.

(2) Ann. Ch. Phys. [3] XXX, 361; J. Pr. Chem. LII, 63.

(3) Sill. Am. J. [2] X, 329.

(4) Petersb. Acad. Bull. VIII, 333.

(5) Dingl. Pol. J. CXVII, 369.

potassa alone. He observes also, that a certain amount of chloride of sodium in the soda prevents the clarifying of the soap.

**Yellow Prussiate of Potassa.**—Gentile(1) gives likewise instructions for an improved method of extracting the cakes, and preparing crude salt from the liquor in the manufacture of yellow prussiate of potassa.

Yellow  
prussiate  
of potassa.

**Gunpowder from Yellow Prussiate of Potassa.**—Augendré(2) recommends a mixture of 1 part of crystallized yellow prussiate of potassa, 2 parts of chlorate of potassa, and 2 parts of white sugar, to be used as gunpowder. This product is said not to explode by friction between two polished bodies, nor by the stroke of metal on wood, but by the stroke of metal upon metal, and to inflame with facility in contact with red-hot or burning substances; it burns then with a larger flame than the ordinary gunpowder, and leaves but little residue. Its action is said to be very stable (because it consists of ingredients of a constant composition), and to be uniform in the granulated and in the powdered state. Farther advantages, according to Augendré, are: its stability in the air; saving of time, inasmuch as it does not require to be so intimately mixed as common gunpowder: in consequence of this, greater safety, because only the pounded ingredients need be kept in store, and they can be mixed according to the demand—an operation which is performed in a very short time. The disadvantages of the new gunpowder are: its oxidizing action on iron gun-barrels, which restricts its application to bronze-barrels and hollow projectiles; next, the rather too rapid inflammability which, although less than that of other exploding mixtures of chlorate of potassa, is still greater than that of the ordinary gunpowder (and, finally, perhaps also the much higher price).

**Sulphate of Alumina.**—Wildenstain(3) has examined a sulphate of alumina of commerce. It formed a white, moist, indistinctly-crystalline mass, lumpy, and of a slightly-sulphurous odour, yielding with water a clear, but very acid solution. The analysis of this product gave: sulphate of alumina, 24.78; sulphate of protoxide of iron, 11.10; free sulphuric acid, 6.76; sulphurous acid and protoxide of manganese, a trace; and farther, 57.35 per cent of water (determined by ignition with protoxide of lead).

**Hydraulic Lime.**—Villeneuve(4), by his observations on hydraulic lime, feels inclined to entertain the opinion, that the hydraulic properties are not solely to be ascribed to the silica, but generally to all

(1) Dingl. Pol. J. CXVII, 414.

(2) Compt. Rend. XXX, 179; Instit. 1850, 58; from Moniteur Industr. in Dingl. Pol. J. CXV, 379; Chem. Gaz. 1850, 198.

(3) J. Pr. Chem. LI, 438.

(4) Compt. Rend. XXXI, 55; Instit. 1850, 225.

Sulphite of  
lead.

electro-negative bodies which form insoluble compounds with lime, especially to carbonic acid. We defer the critique of this view, and of the practical application based on it, until the appearance of the detailed account announced by Villeneuve.

**Sulphite of Lead.**—Scoffren(1) recommends sulphite of lead for paint, in place of white lead, with the especial view of working up this secondary product of his method for refining sugar.

**Sugar of Lead.**—Schneidermann(2) gives a process for the preparation of sugar of lead from pyroligneous acid, which differs from the ordinary method, especially with respect to the purifying of the acid. The rectified pyroligneous acid is exposed to the air for twenty-four hours with an excess of quicklime, stirring it repeatedly, in order to forward the separation of the empyreumatic substances. The clearly-decanted, dark brown solution of acetate of lime is then heated to boiling, and mixed with a solution of chloride of lime, until this ceases to decolorize, when the yellowish-brown solution is evaporated to dryness. The decomposition of the residue (which therefore does not appear to be roasted) with sulphuric acid, is then proceeded with; this is said to furnish an acetic acid but slightly coloured: it is separated from the sulphate of lime by distillation or decantation, and saturated with protoxide of lead (litharge). The amount of hydrochloric acid (from the chloride of lime), and of sulphurous acid and gypsum contained in the acetic acid, cause a slight loss of protoxide of lead which is thus precipitated. The evaporated solution yields yellowish crystals of sugar of lead, which are applicable for many purposes, and for more when recrystallized; their only impurity consists of some chloride of lead.

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**Manufacture of Glass and Pottery. Smalt.**—R. Ludwig(3) has published an elaborate treatise on the properties of smalt, in which he has united his own rich, and practically, very important results with those already known. In the first chapter, he treats on the physical properties, viz.: colour, grain, refracting power, capacity of heat, spec. grav., and hardness. The second chapter is devoted to the chemical properties, especially the composition, the essential and unessential constituents, the influence of the alkaline and earthy bases, and of the heavy metallic oxides on colour, and to the deportment towards water.—In this chapter Ludwig proposes, amongst others, the question: What is the cause of the blue colour

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(1) Chem. Gaz. 1850, 368; Dingl. Pol. J. CXVIII, 157.

(2) Polyt. Centr. 1850, 8; Dingl. Pol. J. CXV, 438; Arch. Pharm. [2] LXIV, 64.

(3) J. Pr. Chem. LI, 129; Dingl. Pol. J. CXIX, 443; Rev. Scientif. Industr., Recettes et Arts, 1851, 65.

produced in smalt by protoxide of cobalt ( $\text{CoO}$ ), the salts of which (even the silicate,  $\text{CoO}$ ,  $\text{SiO}_2$ ) otherwise possess a red hue. A series of synthetical results on the one hand, and a number of analyses, executed by himself, of various kinds of smalt and of zaffer on the other hand, led him to the conclusion, that the colouring substance of smalt is potassio-silicate of protoxide of cobalt,  $\text{CoO}$ ,  $2 \text{SiO}_2$  +  $\text{KO}$ ,  $2 \text{SiO}_2$ , in which the oxygen of the acid is to that in the bases in the proportion of 6 : 1.—The third chapter, finally, enters into more detailed considerations on the properties required in the smalt of commerce, and the mode of testing them empirically. We must refer to the original respecting the numerous details which our want of space prevents us from quoting.—Tomlinson(1) has published a description of the manufacture of smalt in the works of the Erzgebirge.

Smalt.

**Ruby-Glass.**—Völcker(2) found in an antique ruby-glass (from a Roman mosaic floor at Cirencester) oxide of lead, lime, silica, alumina, with sesquioxide of iron and protoxide of copper. He concludes from this, in accordance with former authors, that the ancients understood the way of colouring glass by means of protoxide of copper, and that they took advantage of the reducing action of protoxide of iron to effect this end.

**Porcelain.**—Salvétat and Ebelmen(3) have carried out an investigation of the various products of the manufacture of porcelain at King-te-tching, in Kiang-si (the Staffordshire of the Chinese). Their results are very interesting as regards the history of the industry; we are however prevented, by want of space, from giving a detailed account of them; they led to the conclusion, that the Chinese manufacture of porcelain corresponds entirely with the European as regards raw materials, preparation of the mass, and glazing of the goods; the Chinese porcelain is, however, more easily fusible, than the French at least, and especially that of Sèvres.

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**Agricultural Chemistry. Manure.**—Doubéiran's investigations on humus (comp. p. 413) have afforded him an opportunity of treating of manures in the second chapter of his memoir(4) and on the theory of their application. We think ourselves justified in passing over the analyses he published of some French manures (viz.: poudrette of Montfaucon, stable manure of a farm, and commercial

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(1) Pharm. J. Trans. X, 503.

(2) Chem. Gaz. 1850, 121.

(3) Ann. Ch. Phys. [3] XXXI, 257; J. Pr. Chem. LII, 487.

(4) J. Pharm. [3] XVIII, 5; J. Pr. Chem. L, 415; Ding. Pol. J. CXVII, 372; Instit. 1850, 130 (in abstr.)

**Manure.** manure made from the blood and flesh of horses) as having solely a local interest; and proceed, therefore, at once to the more general propositions maintained by Soubeiran. According to his views, a loss is sustained in the usual nitrogen-determinations of manures, arising from the action of the carbonate of lime on the ammoniacal salts during the process of drying. The mere knowledge of the amount of nitrogen in manures is insufficient, if it be unknown how much of it belongs to the soluble ammonia-salts, how much to the ammoniacal phosphate of magnesia, and how much to the organic matter. For this reason, and because manure contains, in addition to the nitrogenous ingredients, others equally effective, Soubeiran concludes farther, that the amount of nitrogen cannot be taken as a measure of the agronomic value of manure, as has been assumed by Boussingault and Payen. Generally speaking, every theory is objectionable which ascribes the efficacy of manure exclusively to one or the other category of ingredients; the value, on the contrary, is to be estimated by the simultaneous presence and combined action of all those constituents which exercise a decided influence on vegetation. The best manure is, therefore, that which contains, simultaneously: ammonia-salts, nitrogenous substances suitable for the gradual formation of ammonia, ready-formed humus, vegetable tissue in a state of decomposition, and soluble (earthy or alkaline) salts.—The preference of stable manure over other manures is, therefore, self-evident.

A contribution to our present knowledge on the action of manure, and of the organic constituents of soil, has been given by Magnus(1) in the following experiments. Barley-corns were equally well developed, (with stalks of about 15 inches in height, and ears), when sown in a soil prepared for the cultivation of barley, no matter whether this soil was used unchanged, or charred (ignited), or burned (ignited in oxygen). It appears, therefore, as Magnus concludes, that the organic remains in (not newly-manured) soil exert scarcely an appreciable influence. Moreover, barley was sown in earth in these three states; the different lots were then placed under a closed bell-jar, and there provided with air free from ammonia, and with distilled water free from carbonic acid. The sample with burned soil was placed on a vessel of freshly-manured garden soil, which was not used in the two other samples; whilst the two latter produced stalks without ears, of only 7 or 11 inches in length, the former produced stalks of from 24 to 28 inches with ears and grains. The manure exerts consequently a fertilizing influence, as Magnus farther concludes, even without immediate contact with the soil, and therefore only by its organic constituents.

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(1) Berl. Acad. Ber. 1850, 59; J. Pr. Chem. L, 65; Instit. 1850, 245; Chem. Gaz. 1850, 261.

By a synopsis of observations, partly his own, partly those of others, on the relation of the nitrogen in manure to that of the crop, John(1) attempts to prove that an increase of the nitrogen in manure always produces an increase of the absolute amount of nitrogen in the crop; that, however, notwithstanding, the percentage of nitrogen frequently appears to be diminished. John also embraces this opportunity of deducing from the same experiments, "the danger and imperfection of the ash-theory." The original not being at our disposal, we are unable to enter into a more careful examination of these views.

Manure.

Starting from the view that in the disinfection of excrements which are to be used as manure, not only the disagreeable and obnoxious exhalations should be removed, but also the ammonia fixed and the phosphates retained in a form capable of being assimilated by the plants, Calloud(2) finds that the methods hitherto proposed do not satisfy either the one or the other of these conditions, or are too expensive for application. He is of opinion that the mother-liquor of salt-works can be used with great advantage and most perfectly for disinfection.

G. Reich(3) communicates some experiments on the preparation of excrements for manure, and likewise his views on the action of manure; they contain, however, only such information as is known already.

J. Th. Way(4) has made farther communications (see last year's Report, p. 462) on various kinds of refuse, applicable as manure. They comprise: offal of seal-skin and horse-hair, the waste of feathers, of wool-stores and tan-yards, shavings of horn, and dried flesh (with bones) of cattle, imported from Buenos Ayres, the amount of moisture and nitrogen in which has been determined; moreover, elaborate analyses of stable-manure and of the contents of sewers in London. For the details we refer to the original paper.

**Sediment of the Nile.**—Lajonchère(5) has examined a sample of mud of the Nile(a). It consisted of irregular lumps, which could easily be reduced to a finely-divided powder of a distinct saline taste, and which was fatty to the touch; it was mixed with glittering grains. This sample had a spec. grav. of 2.5.—Another specimen(b) examined by Payen and Poinso(6) contained particles of mica, and produced with water a somewhat plastic mass. The analyses gave the following results:

(1) J. Pr. Chem. L, 57.

(2) J. Pharm. [3] XVII, 28.

(3) Arch. Pharm. [2] LXII, 36.

(4) Journ. Royal Agric. Soc. Vol. XI, Part II, page 764.

(5) J. Pharm. XVII, 46; J. Pr. Chem. L, 201; Phil. Mag. [3] XXXVI, 325.

(6) Ibid.





The preceding table contains the composition of the water (per gallon) of the river Trent—viz.: No. 1 in the state as it goes on the land, and No. 2 as it runs off, after the operation is completed. Warping.

From this it is apparent that the water deposited 209·66 grns. of mud per gallon, or 85 cwt. per acre, by 1 foot depth of the water. —Next follows the examination of the mud: No. 1, filtered off from the water No. 1 in the laboratory, dry; No. 2, deposited in the river Humber near its estuary, in the natural state; No. 3 of a middling quality, origin not specified, dry; No. 4, sterile sandy soil, previous to the application of the mud; No. 5, sandy soil, manured 15 years ago with 11 inches of mud; both air-dried. The analyses gave in 100 parts:

|                                            | 1.    | 2.    | 3.    | 4.    | 5.    |
|--------------------------------------------|-------|-------|-------|-------|-------|
| Water . . . . .                            | —     | 47·49 | —     | 1·06  | 2·00  |
| Organic matter . . . . .                   | 7·00  | 5·94  | 6·93  | 2·20  | 7·61  |
| Chloride of calcium . . . . .              | —     | —     | —     |       |       |
| "    magnesium . . . . .                   | —     |       | 0·10  |       |       |
| "    sodium . . . . .                      | —     |       |       |       |       |
| "    potassium . . . . .                   | —     | 1·66  | 0·94  | 0·014 | 0·16  |
| Sulphate of soda . . . . .                 | —     |       | 0·31  |       |       |
| "    magnesia . . . . .                    | —     |       | 0·18  |       |       |
| "    lime . . . . .                        | trace | trace | 0·10  | trace | trace |
| Carbonate of magnesia . . . . .            | 1·52  | 2·60  | 0·31  | trace | 0·29  |
| "    lime . . . . .                        | 9·77  | 3·59  | 8·18  | trace | 0·46  |
| Potassa and soda . . . . .                 | 0·08  | 0·18  | 0·47  | trace | 0·17  |
| Magnesia . . . . .                         | 2·68  | 1·69  | 2·60  | trace | 0·26  |
| Lime . . . . .                             | 0·90  | 0·39  | 0·68  | trace | 0·14  |
| Sesquioxide of iron . . . . .              | 4·46  | 6·63* | 5·05  | 0·28  | 1·17  |
| "    manganese . . . . .                   | trace | trace | trace | trace | trace |
| Alumina . . . . .                          | 4·49  | —     | 8·18  | 0·39  | 0·41  |
| Phosphate of sesquioxide of iron . . . . . | 0·09  | 0·58  | 1·04  | trace | 0·28  |
| Silica . . . . .                           | 68·78 | —     | 9·06  | 0·14  | 2·77  |
| Sand . . . . .                             | —     | 29·15 | 55·87 | 93·87 | 83·57 |
| Stones . . . . .                           | —     | —     | —     | 2·04  | 1·40  |

\* With alumina.

The composition of the mineral constituents of the crop, and their special relation to the application of the mud as manure, is given below, under the analyses of ashes. From the above data, as well as from the spec. grav. and the amount of moisture of the mud in its natural state, Herapath calculates the amount of the individual ingredients of the mud in 18 inches of mud per acre, and compares with it the amount of the ingredients of the ashes in the crop produced on the same space. From these calculations we learn, for instance, that the quantity of phosphoric acid carried on the field in the mud amounts to upwards of 17,000 lbs., whilst a crop of wheat abstracted only 53 lbs.; that, farther, the alkalis in the mud amount to 10,150 lbs., and those in the wheat crop to 13 lbs. only—numbers which prove sufficiently the enormous fer-

**Soils.** tilizing effect of this river-mud. From a comparison of the analyses of the two soils, the same conclusion is deduced.

**Soils.**—It is well known that arable soil is capable of abstracting and of retaining various substances from their solutions, when brought into contact with them. Th. Way(1) has now attempted to ascertain, by an extensive series of observations with the salts and the organic substances occurring in manure, what quantities are thus absorbed by certain kinds of soil (selected from English farms).

**Russian Black Earth.**—The examination of the Russian black earth, the so-called Tschernosem, has been executed by Petzholdt(2), with 3 different samples from the *Gouvernement Tambow*. These samples were derived as follows: No. 1 from manured arable land; No. 2 from meadow land, never before manured, and taken from a low stratum, not accessible to the roots; No. 3 from the surface of arable land, never as yet manured, and worked according to the three-crop system.—None of these 3 samples proved to be completely homogeneous when subjected to mechanical analysis; for, No. 1 contained fragments of glass, bricks, wood, &c., introduced by the manure, and all, on being levigated, yielded a small residue, which Petzholdt recognized under the microscope as fine quartz sand.—For the purpose of the chemical analysis, the soils were freed from the coarser particles by means of a fine sieve, dried between 115° and 120°, ignited, and the humus determined by the loss; the residue left after ignition was extracted by means of hydrochloric acid. The soluble portion was next examined, and the insoluble portion fused partly with carbonate of soda, partly with baryta, and investigated according to the method of Fresenius. For the determination of the chlorine, separate extracts were made by means of nitric acid. Treated in this manner, 100 parts of the black earth yielded:

|                     | No. 1. | No. 2. | No. 3. |                               |
|---------------------|--------|--------|--------|-------------------------------|
| Loss on ignition .  | 18.18  | 9.48   | 8.28   |                               |
| 100 parts residue { | 18.15  | 20.59  | 12.00  | soluble in hydrochloric acid. |
| after ignition . {  | 81.85  | 79.41  | 88.00  | insoluble     "     "         |

The special analysis of the residues of ignition showed the following composition:

(1) Journ. Royal Agric. Soc. Vol. XI, Part I, 313.

(2) Petersb. Acad. Bull. IX, 65; J. Pr. Chem. LI, 1; on the microscopic analysis of the Tschernosem, see Ehrenberg in Berl. Acad. Ber. 1850, 268, besides the additional remarks, *ibid.* 364; J. Pr. Chem. LI, 172.

|                                 | No. 1. | No. 2. | No. 3. |
|---------------------------------|--------|--------|--------|
| Silica . . . . .                | 70·94  | 72·14  | 78·18  |
| Potassa . . . . .               | 5·81   | 2·83   | 3·71   |
| Soda . . . . .                  | 2·31   | 1·75   | 2·01   |
| Lime . . . . .                  | 2·60   | 5·09   | 1·36   |
| Magnesia . . . . .              | 0·95   | 1·37   | 0·58   |
| Alumina and sesquioxide of iron | 17·32  | 17·54  | 16·09  |
|                                 | 99·84  | 100·72 | 101·93 |

Russian  
black  
earth.

The comparison of these results with those obtained by E. Schmid with Tschernosem from the *Gouvernement Oré* (Annual Report for 1849, III, 463), shows a very considerable difference in both kinds of black earth. Whilst Schmid did not find a larger amount of alkalis, earths and phosphoric acid than in other ordinary soils, and ascribed the great fertility of Tschernosem solely to the considerable amount of humus and nitrogen in it, Petzholdt found that this fertility was completely accounted for by the considerable amount of potassa, soda, phosphoric acid and soluble silicic acid (7 to 8 per cent) observed by him.

**Humus and Mould.**—Soubeiran(1) has published an essay to which a prize was given by the Agricultural Association of Rouen, on "Humus and the function of manure in the nutrition of plants." We have already, p. 437 of this Report, discussed the portion relating to manure and its functions. That part is much more comprehensive which treats of humus, of mould, and of peat.

The mould (*terreau*) used in these experiments was derived from the *Jardin des plantes* in Paris. Alcohol extracted from it an inconsiderable amount of fatty or resinous substances. Water was coloured yellow when in contact with it for some time, dissolving, in addition to nitrates, sulphates, phosphates and chlorides—which, as Soubeiran supposes, form the vehicle—an organic substance (not farther investigated).—Ammonia, of any strength, produced when the air was excluded, a slightly coloured solution which gave with acids only a trifling precipitate; on the contrary, when the air had access, it produced dark brown solutions which yielded, with acids, bulky precipitates.—Mould, previously washed with dilute acids, was freely dissolved by ammonia without the intervention of air.—Humate of lime (prepared by double decomposition of humate of ammonia and chloride of calcium) gave, with cold as well as warm ammonia, slightly yellow solutions; with carbonate of ammonia, however, copious, dark-coloured solutions; the same was the case with mould.—Mould, successively exhausted with water, hydrochloric acid and ammonia, again produced coloured solutions with ammonia, when, after being

(1) J. Pharm. [3] XVII, 321; J. Pr. Chem. L, 291; Dingl. Pol. J. CXVII, 61; *Instist.* 1850, 130 (in abstr.)

Humus  
and  
mould.

so treated, it was exposed to the air for a long period; the same took place, with absorption of oxygen, when mould thus exhausted was brought into contact with this gas in a bell-jar over mercury; it was effected, even in a few moments, when ammonia was present, and still more rapidly with a fixed alkali (carbonated or free). Soubeiran could repeatedly expose the same mould to oxygen, and, after washing it, still obtain coloured solutions by the same procedure.—Brown rotten wood (of oak) behaved exactly like mould when acted on by water, air, alkalies and acids, differing however in this respect that the rotten wood produced with alkalies dark brown solutions without being previously treated with acids.—A sample of peat(1) from the neighbourhood of Corbeil exhibited in its natural state an acid reaction which did not disappear even after protracted washing. The water was not coloured. Brought in contact with air in a bell-jar over mercury, no appreciable absorption nor formation of carbonic acid took place even after it was in contact for three months; both these phenomena ensued, however, very energetically, when the peat was previously moistened with ammonia. Peat, like mould, produced dark-coloured solutions only when previously treated with acid.

Soubeiran concludes, from these observations, that the three natural products which he examined, contained humus (*l'humus*) partly free, partly combined with lime, along with an organic substance convertible into humus; that in the mould and in the peat the free humus is very small in quantity when compared with the humus combined with lime, whilst it predominates in the rotten wood; that humate of lime is converted into soluble humate of ammonia by double decomposition with carbonate of ammonia. Lastly, his experiments show, that a copious formation of humus is effected by the influence of air and alkalies. He considers, accordingly, rotten wood as a very pure mould, and is of opinion, that peat, in the state into which it is transformed by the influence of air and alkalies, possesses all the qualities and characteristics of mould.

It is evident that Soubeiran means by "*humus*" the brown substance which, under various circumstances, is extracted by ammonia from mould and from the corresponding products. In order to prepare it, he treated mould with hydrochloric acid, removed the excess of acid by distilled water, extracted the residue with ammonia, and precipitated the humus from the brown ammoniacal solution by means of hydrochloric acid. The precipitate thus obtained was shown by a special experiment to consist partly of a combination of humus with hydrochloric acid, insoluble in water but soluble in alcohol; it was successively washed with water, alcohol and ether(a). The substance

(1) In the continuation of the above paper, mentioned page 437 (J. Pharm. [3] XVIII, 16.)

thus obtained and also humus prepared by the same process from rotten wood(b), and from peat(c), gave on ultimate analysis, in 100 parts :

Humus  
and  
mould.

|   | Carbon.      | Hydrogen. | Nitrogen.  | ..... |
|---|--------------|-----------|------------|-------|
| a | 55 to 57     | —         | 2.0 to 2.5 | —     |
| b | 55.0 „ 55.3* | 4.8*      | 2.5*       | 7.16* |
| c | 54.0*        | 4.61*     | 2.4*       | 10.0* |

\* After deducting the ash.

Respecting the amount of ash in the humus(a) no mention is made ; as little information is given concerning the quality of the ashes in (b) and in (c), and the quality of both precipitates generally, especially with regard to their purity. The analyses lead, as a whole, to no constant composition. The nitrogen, at least part of it, Soubeiran considers to be an essential ingredient, without producing, however, farther proofs of this opinion. He observes that the amount of nitrogen in rotten oak wood was larger than that in the sound wood and he thinks that this excess is to be ascribed, with great probability to an absorption from the atmosphere, rather than to insects, &c. Concerning the variations of the carbon, Soubeiran is convinced that the amount of this element depends on the influence of the atmosphere, so that it is increased by the continuance of this influence ; he considers that this is proved by an experiment in which he succeeded in raising by 4 per cent the amount of carbon in humus (prepared as above) by dissolving it in a dilute solution of soda and boiling the solution for forty hours. Notwithstanding this, he attempts, immediately after, to refute the opinion—that humus becomes richer (relatively) in carbon by the continued influence of the air, and is thus converted into mould (*pourri*)—by another experiment which he thinks, proves that humus scarcely changes a given volume of air, and scarcely acts even when ammonia is present. There exist but 2 products of transformation of wood, according to his opinion. He says that air changes wood at first into a humus-like body insoluble in alkaline liquids, the *humus-coal* (*terreau charbonneux*), which in its turn, by the continued action of the air, and with disengagement of carbonic acid, is rendered soluble in alkalies and then forms humus (*l'humus*).

In the last chapter Soubeiran treats of the part which humus plays in the nutrition of plants, and attempts to show that this substance is absorbed as such by plants for food. For, he says amongst other things, what other purpose should humus serve ? The experimental proof, however, is given by the following results : The carefully cleaned roots of a specimen of *Lapsana communis* were immersed (the light being excluded) in a very dilute, neutral solution of humate of ammonia, which was replaced daily by a fresh solution. The solutions used, after being brought to their original

Humus  
and  
mould.

volume by the addition of distilled water, appeared then, in every instance, paler than they were before. Farther, oats and beans sown in ignited earth mixed with bone-ash and gypsum, and sprinkled with a weak solution of humate of ammonia, thrived exceedingly well, and produced flowers and seeds. It will be superfluous to enter farther into the force of arguments based on such experiments. Soubeiran regards the direct nutrition of plants by humus as established by these experiments, and he believes that the carbonate of ammonia is the important agent which abstracts the humus of the soil from the lime, renders it soluble, and thus conveys it to the plants. As regards the opposite opinion of Liebig, which excludes such a direct supply, and views the humus simply as a source of carbonic acid, it is, as a matter of course, rejected by Soubeiran, who thinks the arguments in favour of it are no longer valid. We refer here simply to the reply which Liebig(1) at the time made to similar objections by Saussure, based, however, on quantitative experiments.

**Influence of Chloride of Sodium on the Development of Plants.**—Völckér(2) has made some experiments on the influence of chloride of sodium on plants. A solution of 24 grs. to 1 pint of water proved injurious to *Anthoxanthum odoratum* only (amongst the grasses subjected to the experiment), but not to the other grasses and to cabbage, beans, onions and lentils; a solution of 48 grs. to 1 pint agreed with cabbage, lentils, radishes; a solution of 96 grs. to 1 pint with onions, radishes, *Carduus pratensis*. The onions grow even when treated with a solution of 192 grs. to a pint.

**Influence of Gypsum.**—Mène(3) has made experiments on the influence of gypsum on vegetation. Plants sown in artificially precipitated gypsum, germinated as well as in earth, but died after a fortnight; in a mixture of equal parts of gypsum and clay-soil (*terre argileuse*) they thrived but badly; exceedingly well, however, in gypsum stratified with manure. Mène convinced himself by special experiments that gypsum decomposes the carbonate of ammonia of the manure, and he is therefore of opinion, that the efficacy of gypsum depends solely on this reaction on ammoniacal salts.

**Influence of the Constituents of the Soil generally.**—Magnus(4) has repeated the experiments of Salm-Horstmar (comp. Annual Report for 1849, III, p. 464) on the superfluity or necessity of the various mineral constituents of soil; he used barley instead of oats, retaining, however, the method of experimenting. The seeds were sown, as in the other experiments, partly in pure sugar-charcoal, partly in sugar-charcoal with which various salts were mixed, representing the

(1) Ann. Ch. Pharm. XLII, 291.

(2) Instit. 1850, 382.

(3) Compt. Rend. XXXI, 803; Instit. 1850, 394; Arch. Ph. Nat. XVI, 149.

(4) Loc. cit. p. 438.

bases and acids occurring in the ashes of plants, and sprinkled with a solution of 1 part of carbonate of ammonia in 1000 parts of water. Although the experiments did not lead to a result with regard to the question in view, on account of an accident, they nevertheless showed that barley cannot be developed without the substances composing the ash, and they also led to some peculiar observations.—In the first experiments, when the total quantity of the salts amounted to 15·5, and that of the soluble ones to 5 per cent of the sugar-charcoal, the corn sown was either sparingly or not at all developed. On washing the sugar-charcoal, however, and sowing afresh, the new seed was developed much more vigorously, and produced a stalk 14 inches in length, but no ears.—Perfectly similar experiments, in which the charcoal was replaced by felspar-powder, produced a like result. Barley sown in pure but coarsely powdered felspar, produced stalks of 11 inches with from 5 to 7 leaves without ears; in an experiment, made by way of checking the former, with  $\frac{1}{3}$  of levigated felspar the stalks attained to a height of 20 inches, and produced ears with grains.

Influence of the constituents of the soil generally.

**Influence of Pure and Unmixed Mineral Substances upon the Development of the Vegetable Substance.**—E. Wolff(1), in an extensive treatise “On the influence of the pure and unmixed mineral substances upon the development of the vegetable substance,” has published the commencement of an investigation which has for its object to establish “A scientifically as well as practically correct theory of manure.” The special object at present treated of, is the influence of mineral substances—viz.: common salt, nitrate of potassa, crystallized soda, purified potashes, sulphate of magnesia, Glauber’s salt and lime crumbled down in the air—on the yield, that is, on the weight of the crops irrespective of their composition. This subject is however preceded by another series of experiments on a totally different question, viz.: whether in a soil completely free from humus, different quantities of mineral bases effect a difference in the composition of the ashes of the plants grown on it. Although the analyses of these ashes are reserved for a future communication, and the question referring to them remains therefore open for the present, yet the mineral substances above named, the same plants, and perfectly analogous observations, are taken into consideration in the later part of the paper. We have to observe, that the conditions were not the same in both cases, inasmuch as, in the first series of experiments, the salts were mixed with wood-ashes (containing peat-ashes), the composition of which is but imperfectly given, whilst in the other experiments the salts were mixed with the soil without this addition. Farther, whether the experiments of the first

(1) J. Pr. Chem. LI, 15; critical remarks, see Arch. Ph. Nat. XVI, 236.



Influence  
of pure and  
unmixed  
mineral  
substances  
upon the  
develop-  
ment of the  
vegetable  
substance.

series, which were undertaken on the sub-soil of an ordinary sandy field, covered with gravel, thus fulfil the condition of a situation completely free from humus, remains doubtful, as specified information on this point is not given.—For the experiments of the second series, “a light, active middle soil of a sandy nature” was used (its composition was not examined); after the proper mechanical preparation, it was divided into 40 beds of 3 square feet each, and the above mineral substances applied in such a manner, that for chloride of sodium, nitre and potashes each 7, for soda and Glauber’s-salt each 6, for lime and sulphate of magnesia each 3 beds were used, the substances being applied in increasing doses, and 1 bed consequently remained free to serve as a control. Each bed was again sub-divided into 3 beds of 1 square foot each, which received respectively seeds of barley, oats and buck-wheat. After the harvest the beds were simply loosened and, without farther application of manure, each division was respectively sown with winter rye, winter wheat and clover (what sort?) in order to study the lasting effects of these salt-manures. By this mode a series of crops was obtained, corresponding to the whole series of the first experiments, which was used for farther observations. As has been already mentioned, these experiments are first of all intended to serve for establishing the absolute weight of the plants, or parts of plants, grown on each subdivision. In most cases, however, a definite statement is wanting whether the plants were weighed in the dry or in the fresh state. When, farther, Wolff, in the introductory part of his treatise, points out the advantages of making such experiments upon the small scale, no objection can be made on this point; when, however, for the purpose of drawing his conclusions and considerations from those observations, he extends the results immediately obtained to 1 hectare of surface, we are forced to doubt the correctness of such a representation, viz.: the conclusion from 1 to 54,000, from the gramme to the hundred-weight.

The preceding observations may suffice to show the uncertainty of such experiments with regard to the conclusions drawn from them. The results obtained are only valid for the special circumstances of the experiment, and as these circumstances have not all been investigated, the results depend partly on unknown conditions. How is it possible, in a precise manner, to eliminate the influence of the admixed salts, if we do not know the constituents of the soil? How can we guarantee the purity of the results, or the isolation of the particular experiments, when we consider the minuteness of the experimental beds, and their close proximity? The conclusions which Wolff is induced to draw, and from which we extract only a few principal points, have therefore to be received with great caution.—According to Wolff, the potashes act favourably on the produce, in the case of all plants, but more so on the leaves

than on the fruit, and this influence is lasting. Soda also effects an increase of the produce, but a much smaller one; and in the case of buck-wheat, none at all. Chloride of sodium acts decidedly unfavourably when humus or nitrogenous substances are absent; but favourably when these are present, especially with the cereals; its action is, however, not lasting. With an increased quantity of chloride of sodium applied as manure, the increase of the produce has two culminating points, in the case of barley as well, as in that of oats, viz.: it rises at first, decreases, and then rises a second time, and decreases at last again. The same effect is produced by soda upon clover. Saltpetre acts favourably, but not on the formation of fruit, and not at all lastingly; so did lime. The influence of bitter salt and Glauber's-salt is almost indifferent.

Influence of pure and unmixed mineral substances upon the development of the vegetable substance.

We shall have occasion, in our Report for the next year, to return to these experiments, especially with regard to the relation between the composition of the ashes of the plants and that of the salt-manure.

Experiments quite analogous to those of Wolff have been made by J. Pierre(1) on the influence of salts as manure, on lucerne (variety à deux coupes); they were performed on land which had been manured in 1845, and sown with turnip seed; in 1846, not manured and sown with wheat; in 1847, partly manured, and again cultivated with wheat. For the purpose of the experiment (which succeeded the wheat without interval), this field was divided into 48 beds of 75 square metres each; of these beds, some were left unchanged; the majority, however, were manured with the salts to be tried, in various doses. At the harvest, the weight of the crop of each division was determined, and thus results were obtained from which Pierre draws the following conclusions. The salt-manures applied, can be divided into 4 categories with regard to their effect on lucerne. The manures of the first class effect an increase of the produce for all 4 crops or cuttings; to this belong(2): nitrate of ammonia ( $16\frac{2}{3}$ ), nitrate of soda ( $33\frac{1}{3}$ ), unburned gypsum ( $266\frac{2}{3}$ ), sulphate of soda ( $133\frac{1}{3}$ ), a mixture of burned gypsum ( $133\frac{1}{3}$ ), with chloride of sodium ( $16\frac{2}{3}$  or  $33\frac{1}{3}$ ), sulphate of potassa ( $33\frac{1}{3}$ ) and nitrate of ammonia ( $33\frac{1}{3}$ )—arranged according to their efficacy in a descending scale. The second class comprises salt manures, which increase the produce of one or more crops or cuttings, without diminishing the produce of the other cuttings; to this belong: sulphate of potassa ( $16\frac{2}{3}$ ), nitrate of potassa ( $16\frac{2}{3}$ ), and a mixture of burned lime ( $133\frac{1}{3}$ ), with chloride of sodium ( $33\frac{1}{3}$ ). The salt-manures of the third class increased the produce of one or several of the

(1) Compt. Rend. XXXI, 547; Arch. Ph. Nat. XVI, 233; Ding. Pol. J. CXVIII, 427; more in detail, Ann. Ch. Phys. [3] XXX, 410.

(2) The numbers within brackets denote the doses, expressed in kilogrammes to 1 hectare.

Inorganic  
constituents of  
plants.

cuttings—diminished, however, that of the rest. To this belong: burned lime ( $266\frac{1}{3}$ ), sulphate of soda ( $66\frac{2}{3}$ ), sal-ammoniac ( $33\frac{1}{3}$ ), the same ( $66\frac{2}{3}$ ), carbonate of potassa ( $33\frac{1}{3}$ ), the same ( $66\frac{2}{3}$ ), chloride of sodium ( $133\frac{1}{3}$ ), carbonate of soda ( $133\frac{1}{3}$ ). Lastly, the salt-manures of the fourth class, viz.: chloride of sodium ( $66\frac{2}{3}$ ), carbonate of soda ( $66\frac{2}{3}$ ), diminished the produce of all 4 crops or cuttings.

**Inorganic Constituents of Plants.**—The prize-question proposed by the philosophical faculty of Jena—whether the quantity of the inorganic constituents of the same plant and of the same organ varies in the different periods of vegetation?—has been answered by E. Staffel(1), in an extensive and analytical inquiry concerning the horse-chesnut and the walnut, and the results were published in an essay which obtained the prize. Staffel used for this purpose the wood and the bark of sprouts one year old, and selected perfectly healthy leaves, free from spots. The material was gathered on the 1st of September, 1849, and 6th of May, 1850, from a middle-sized horse-chesnut tree of the Princess Garden (here, Jena or Weimar?); and on the 27th of August, 1849, and 31st of May, 1850, of a walnut tree, on the Hausberg, near Jena. The analytical investigation has been executed after the method of Wackenroder, with this difference however, that the vegetable substances were not incinerated immediately, but first charred, the charcoal extracted with water, and the exhausted charcoal then incinerated by itself. The charcoal-ash thus obtained was also first extracted by means of water, and then the soluble and insoluble portions, and the aqueous extract of the charcoal, each separately analyzed. From the separate results the complete composition of the ashes was then calculated, as given in the Table D, Nos. 115 to 120 inclusive, for the horse-chesnut; and Nos. 121 to 126 inclusive, for the walnut tree, along with the percentage of ashes and the amount of moisture in the plant. The essential portion of these results is comprised in the following:

- 1. With regard to the horse-chesnut: The amount of ash of the dry (but not of the fresh) vegetable substance in wood and bark is larger in spring than in autumn, and is about the same at both periods in the leaves. That portion of the mineral constituents which is extracted by water from the charred substance, is to that not extracted by water; in spring, in wood or bark, as 3 : 2; in leaves, as 1 : 2; in autumn, in wood, as 2 : 11; in bark and leaves, as 2 : 7; in round numbers. The amount of oxygen in the bases does not vary much, for the same period of the year, in the three parts of the plant; but in autumn it is universally larger than in spring.

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(1) From the Prize Essay, with a few abbreviations, in Arch. Pharm. [2] LXIV, 1, 129; Ann. Ch. Pharm. LXXVI, 379 (in abstr.); see E. Wolff, Annual Report for 1847 and 1848, II, 321.









The composition of the ashes shows, as the most important of the more general phenomena, the entire absence of soda in all cases (although Staffel expressly tested for this body), as well as the frequent occurrence of alumina. Concerning the particulars of the question, before us, essential differences were found in the composition of the ash of the same organ in spring and in autumn, and by far the most striking in the case of lime and potassa. Potassa preponderates in spring to such a degree, that its amount reaches 9 times that of the lime; whilst in autumn this relation is reversed, and the amount of potassa sinks below  $\frac{1}{3}$  of that of the lime. The amount of phosphoric acid in the wood remains almost the same in both periods of the year; it is, however, in bark and leaves, almost 3 times as large in spring as in autumn. Silica and sulphuric acid increase from the wood through the bark to the leaves, as has been already found by E. Wolff(1). The same was the case, but, in contradiction to Wolff's statement, with sesquioxide of iron, of which the latter could not find any appreciable amount. The least variation is shown in the amount of magnesia in the ashes. The amount of chloride of potassium is decidedly larger during spring, in wood and bark, and during autumn in the leaves.

2. With regard to the walnut: The amount of ashes in the organs, and the amount of oxygen in the bases, showed the same relations as in the case of the horse-chesnut, but not so the portion of the charred substances which could be extracted by water, to that not extracted by this solvent; for the former almost equals the latter in spring, but in autumn the proportion of the former to that of the latter is about as 2 : 9 in wood, 1 : 11 in bark, and 1 : 3 in leaves. Respecting the composition, the statements adduced for the horse-chesnut hold good also for the walnut, with regard to soda, alumina, phosphoric acid, magnesia, as well as potassa and lime. Sulphuric acid and silica, however, diminish from the wood to the leaves; and the same is the case with the sesquioxide of iron. Finally, the amount of chloride of potassium is remarkable; it is  $\frac{1}{3}$  to  $\frac{1}{4}$  less in the walnut, as compared with that in the horse-chesnut.

In a supplement to his examination of the constituents of the ashes of the horse-chesnut(2), E. Wolff(3) endeavours to remove some doubts which have been raised as to the correctness of his estimations, and to render his results comparable with those of Staffel. Concerning the first question, Wolff points out that, in the analysis of the ash of the horse-chesnut wood, the amount of alkali, left on extraction with water, was always determined in

(1) Annual Report for 1847 and 1848, II, 321.

(2) Annual Report for 1847 and 1848, II, 321.

(3) J. Pr. Chem. LII, 122.



the hydrochloric extract; and that, therefore, C. Bischoff is in error when he states the contrary. That the observation respecting the amount of soda in ashes of wood, also made by Bischoff (*Annual Report for 1849*, III, p. 467), was not applicable to that of the horse-chesnut, inasmuch as this did not contain any soda. Moreover, in the method used by him, no appreciable error in the determination of the sulphuric acid could have been occasioned by a disengagement of sulphuretted hydrogen, on treating the charred substance with hydrochloric acid. The variations in the amount of chlorine might, however, very probably proceed from the method of analysis, inasmuch as the quantity of chlorine retained by the charcoal, after the extraction with water, was only indirectly calculated from the amount of the alkalis. Wolff does not make mention of the very considerable difference in the amount of sesquioxide of iron in his analyses and those of Staffel, which the latter ascribes to an erroneous observation of the former.—Concerning the second point—the attempted reconciliation of the differences of both analyses, is based on “calculations and reductions;” the admissibility of which is left to the decision of the reader. The nature of these calculations may be shown by the following example, selected from the rest. Staffel has analyzed the entire leaf, Wolff the stem with the ribs, and the soft substance of the leaf, separately: now, in order to render both analyses comparable, Wolff calculates the composition of the whole leaf, and takes for this purpose simply the arithmetical mean of the percentage composition of the ashes of the stem, and of the soft substance of the leaf. The motive for this calculation is “an assumption approaching to truth,” according to which the absolute amount of ash in both portions of the leaf is about equal. If this assumption (which is, however, by no means proved) be correct, it is erroneous when Wolff puts down the percentage of the ash of the entire leaf as equal to the arithmetical mean of the percentage of ash in the stem (13·37), and in the soft substance of the leaf (9·08). Wolff says he makes reductions when, for instance, “the amount of sesquioxide of iron and alumina is distributed amongst the rest of the constituents.”

**Ashes of Plants. Vine.**—Boussingault(1) has investigated the quantity of mineral substances of which the soil is deprived by the cultivation of the vine, and has used for this purpose the products in the year 1848 of a vineyard of 170 acres in his farm (in Alsace). Since the leaves remain with the soil, the products actually removed from the vineyard are confined to the wine, to the husks, and to the small-wood removed in the operation of cutting the vines. Of each of these, the total quantity, the amount of ashes, and the composition of the ashes was determined; and from

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(1) *Ann. Ch. Phys.* [3] XXX, 369; *J. Pr. Chem.* LII, 37.

the result obtained, the quantity of each substance abstracted from the soil was calculated, in order to compare them with those abstracted by other cultivated plants. There were obtained: 55·05 hectolitres of wine, containing (1·87 grms. per litre) 10·294 kilograms of ashes; farther, 492 kilograms of air-dried husks containing 6·65 per cent, or 32·72 kilograms of ashes; lastly, 2624 kilograms of small-wood, with 2·44 per cent, or 64·03 kilograms of ashes: The analysis of these ashes (made by Houszau under the direction of Boussingault) is given in Table D, Nos. 127, 128, and 129. Boussingault calculates now from these results the constituents of the soil abstracted from the 170 acres, and compares them with those abstracted from land of an equal surface (in the neighbourhood of the vineyard) by the undermentioned plants (according to his former determinations), in kilograms, as follows:

Ashes of  
plants.  
Vine.

| Removed by:      | Potassa. | Soda. | Lime. | Mag-<br>nesia. | Phosphoric<br>acid. | Sulphuric<br>acid. |
|------------------|----------|-------|-------|----------------|---------------------|--------------------|
| Wine . . . .     | 11·53    | 0·13  | 17·48 | 3·91           | 6·66                | 1·02               |
| Husks . . . .    | 12·07    | 0·13  | 3·50  | 0·72           | 3·50                | 1·77               |
| Small-wood . .   | 4·64     | —     | 0·51  | 0·95           | 2·27                | 0·53               |
| Total . . . .    | 28·24    | 0·26  | 21·49 | 5·58           | 12·43               | 3·32               |
| Potatoes . . .   | 107·1    | —     | —     | —              | 23·8                | —                  |
| Beetroot . . .   | 153·0    | —     | —     | —              | 20·4                | —                  |
| Wheat with straw | 45·9     | —     | —     | —              | 323·0               | —                  |

From this it results that the cultivation of wine does not remove from the soil more potassa (alkali) than that of the cereals and roots.

**Wheat.**—W. Baer(1) has published a continuation of his investigation on the ashes of plants (Annual Report for 1849, III, p. 478), which treats of the composition of the ashes of wheat (corn and straw from the same field). By omitting all statements regarding the cultivation of the corn, as in his former investigation, Baer deprives this work, as he did his former, of its chief interest. We confine ourselves, therefore, to the communication of his results (Table A, Nos. 6 and 7), and remark that it has not been mentioned whether the amount of ashes refers to the dried or undried substances.

Th. J. Herapath(2) also examined the ash of wheat, in reference to the manuring with mud by artificial inundation (see page 440). The succession of the crops was as follows: after the application of the mud, common field-beans, then successively wheat, Nos. 1, 2, and 3 (wheat Nos. 4 and 5 have been cultivated in the neighbourhood

(1) Arch. Pharm. [2] LXI, 267; Ann. Ch. Pharm. LXXVI, 381 (in abstr.)

(2) Loc. cit. p. 440.

Rye.

of Bristol without mud-manure, and have only been added for the sake of comparison), of the Table A; after that, followed oats twice.

**Rye.**—A similar comparison is afforded by the analyses of rye-ash; No. 8 of Table A is from soil, manured with mud; No. 9 from an ordinary sandy soil.

**Oats.**—The composition of the ash of the first crop of oats above-mentioned is given in No. 19, Table A; that of the second in No. 20. In oats and rye the amount of potassa and phosphoric acid appears somewhat increased by the mud-manure; but not so in wheat.

J. Th. Way and G. H. Ogston(1) have continued their investigation (Annual Report for 1849, III, 471) on the ashes of cultivated plants. They have retained the object they had in view, and also their method of incineration and analysis; we have, therefore, little to add to their results which are given in Table A. They refer first to oats (Nos. 10 to 18 incl.) of the harvest of 1847. It will be perceived that the ash of oats contains in general less phosphoric acid and potassa than that of wheat; it does not, however, according to Way and Ogston, deprive the soil on this account of a smaller quantity of both substances, because this difference is balanced by the larger amount of ashes in oats.—J. A. Porter(2) has also communicated analyses of the ash of oats (No. 21, Table A), of hay, and of the wash of a distiller. These analyses have been made according to the method of Will and Fresenius; the alkalies were determined by the indirect method.

**Barley.**—Way and Ogston(3) have farther given a new series of analyses of barley-ash (Nos. 22 to 35 incl. of Table A), all from the harvest of 1847. The difference in the amount and the composition of the ash of barley-straw, No. 33, compared with that of Nos. 34 and 35, is very striking. The analyses of the ash of various parts of the Indian corn-plant (Nos. 36, 37, and 38, Table A), have also been made by Way and Ogston(4). They show that the very large produce of Indian corn (it surpasses that of wheat by about  $\frac{2}{3}$ ) is not to be deduced from a smaller assimilation of the constituents of the soil.

**Millet.**—The composition of the ash of the millet (No. 39, Table A) from the Geisberg near Wiesbaden has been determined by Wildenstein(5), according to the method of Will and Fresenius.

**Field-bean.**—Respecting the ash of the common field-beans (No. 74, Table B), compare the treatise of Herapath mentioned page 440.

(1) Journ. Royal Agric. Soc. Vol. XI, Part II, 497.

(2) Sill. Am. J. IX, 20; Ann. Ch. Pharm. LXXVI, 382.

(3) Loc. cit. p. 440; Journ. Royal Agric. Soc. Vol. XI, Part II, 502.

(4) Ibid. p. 508. The cultivation of maize in America has been more extensively treated by J. H. Salisbury in his work (as yet not met with by us) entitled: "History and Chemical Investigation of Maize, or Indian Corn," Albany, 1849 (200 pages).

(5) J. Pr. Chem. XLIX, 152; Ann. Ch. Pharm. LXXVI, 383.

**Grasses.** **Hay.**—J. Th. Way and G. H. Ogston(1) have analyzed the ashes of various grasses used in the cultivation of meadows; Nos. 40 to 57 incl., Tables A and B. The species examined have been gathered on meadows, and were not separately cultivated: they are all rich in silica and potassa. The same chemists(2) have published the analysis of the ash of Italian rye-grass-seed, Table B, No. 58; of meadow-grass(3) from two successive cuttings, Table B, Nos. 50 and 60; and of meadow-hay(4), Table B, No. 61, from another locality. From the analysis of the meadow-grass, and from the observed produce of the same, it results that no other crop deprives the soil of so large a quantity of mineral substances (795 lbs. per acre). The irrigation seems simply to increase the amount of the produce without exercising any influence on the composition of the ash.—Porter(5) gives also, in the notice already quoted, p. 454, the analysis of the ash of hay, Table B, No. 62, without farther details.

**Cabbage and Turnips, &c.**—The continuation of the investigation by Way and Ogston on the ashes of cultivated vegetables, which has been mentioned above, comprises farther the analysis of the ashes of cow-cabbage(6), Nos. 63 and 64 of cohl-rabi(7), Table B, Nos. 65 and 66; of the commercial seed of white turnips, No. 67, and of that of mangel-wurzel(8), No. 68; of the leaves of rape(9), No. 69; of commercial white mustard-seed(10), No. 70; of carrots(11), No. 71 and 72; and of the commercial seed of the same(12), No. 73; of commercial seed of lucerne(13), No. 75; of a series of fodder, particularly species of clover(14), as entire plants, Nos. 76 to 84 incl.

**Flax-plant.**—A considerable part of the investigation of Way and Ogston is devoted to the flax-plant(15) in its various organs and with reference to its technical preparation, and the constituents of its ash, (Comp. R. Kane's investigation, Annual Report for 1847 and 1848, II, 327; and Mayer and Brazier's analyses, Annual Report for 1849, III, 481). The results are given in Table C, Nos. 85 to 95 incl.—viz., Nos. 85 and 86, the entire stalk; the former of a variety with fine fibres cultivated on clay-soil in the year 1847; the latter of a variety with coarse fibres, both without seed-vessels; No. 87, the seed; No. 90, the leaves of No. 85 in the

(1) Journ. Royal Agric. Soc. Vol. XI, Part II, 530.

(2) Ibid. 516.

(3) Ibid. 539.

(4) Ibid. 538.

(5) Sill. Am. J. IX, 20; Ann. Ch. Pharm. LXXVI, 382.

(6) Journ. Royal Agric. Soc. Vol. XI, Part II, 512.

(7) Ibid. 511.

(8) Ibid. 516.

(9) Ibid. 513.

(10) Ibid. 516.

(11) Ibid. 511.

(12) Ibid. 516.

(13) Ibid. 536.

(14) Ibid. 536.

(15) Journ. Royal Agric. Soc. Vol. IX, Part II, 517.

*Armeria  
maritima.*

Table D, from a place accessible to the splashings of the waves, No. 132 from a high granite rock opposite, No. 133 from a nursery-ground near Edinburgh. It appears that the first specimen contains (4.47 per cent) of soda in addition to (24.03) of chloride of sodium, the second only chloride of sodium (18.44), the third none of either.

**Distiller's Wash.**—Porter(1) has analyzed the ash of a wash from the distillation of potato brandy (Table D. No. 134).

**Alimentary Substances.**—On the 'preservation of meat by means of chloroform, comp. p. 309 of this Report.

**Wheat.**—Rau(2) also doubts, as did Schlossberger(3) and others, the correctness of the numerical values given by Hermbstädt(4) for the amount of gluten and starch in wheat after the application of different manures. He shows that these values can be made to agree with the recent observations, by the simple assumption that, in the statements of the amount of gluten, the figure 1 in the place of the thousands is to be left out as being derived from an error in the manuscript.

Millon(5) has made a remarkable observation concerning the amount of moisture in wheat grown in the year 1850, a year in which the crop was much disturbed by heavy showers of rain, and the corn became so wet that it germinated partly on the stalk. Such unfavourable circumstances led to the expectation that an unusual amount of moisture would exist in the corn; comparative experiments with wheat of former years (from various localities in the arrondissement of Lille) gave, however, the following amounts of moisture in 100 parts of wheat, viz.:

|                                  |  |          |          |       |
|----------------------------------|--|----------|----------|-------|
| A sample of the year 1847 . . .  |  | 18.5     |          |       |
| " " 1848 . . .                   |  | 14.0     |          |       |
|                                  |  | Maximum. | Minimum. | Méan. |
| 7 samples of the year 1849 . . . |  | 17.70    | 16.50    | 17.07 |
| 8 " " 1850 . . .                 |  | 16.05    | 15.22    | 15.56 |

The wheat of 1850 belongs, therefore, decidedly to the most dry, and is in this respect only exceeded by that of 1848. Millon finds the clue to this anomaly by comparing the unsifted and sifted flour of the wheat, which shows that the former contains 0.5 per cent more of moisture. He thinks that this might amount to 2 per cent if the wheat were ground on the large scale; the smallness of his samples prevented him from verifying this supposition. It is there-

(1) Loc. cit. p. 454.

(2) Ann. Ch. Pharm. LXXIV, 108.

(3) Annual Report for 1847 and 1848, II, 314.

(4) Wägelin'sche Annalen der Landwirthschaft, XIX, 41; XXII, 1.

(5) Compt. Rend. XXXI, 747; Instit. 1850, 378.

fore evident, he says, that the rain enters merely the integument, and not the interior of the corn, and that the obnoxious influence on the preservation of the flour could easily be met by a rapid separation of the moist bran from the flour by means of sifting.

Wheat.

A. Dubois(1) confirms, by his own practical experience, the statement of Millon, mentioned in last year's Report, p. 490, that the corn is deprived of much nutriment by the removal of the bran.

**Adulteration of Flour.**—Martens(2) subjects to a minute criticism the various methods for the detection of the adulterations of flour with other articles of consumption, and he states, on this occasion, his views on those points which should serve as guides in forensic investigations of this subject.

According to Donny and Mareska(3), an admixture of as little as 1 per cent of the flour of buck-wheat to wheaten flour can be recognized with the microscope by the regular polyhedric form of the starch-grains of the former.—An admixture of linseed meal, they say, cannot be readily discovered by determining the amount of mucilage; it may, however, be done by the following method: a solution of potassa of 14 per cent brought into contact with linseed meal, produces small, regular, glassy and red fragments derived from the integument of the seed, and by this means an admixture of 1 per cent of linseed meal to the flour may be detected. The amount of oil, which is still considerable in the cakes of linseed meal, may likewise be used for this purpose; in this case the adulterated substance is to be extracted by means of ether, and the fat thus obtained (in order to distinguish it from the oil of rye) treated with fuming nitric acid which forms with it a solid, beautifully red mass, insoluble in boiling alcohol.

**Brown Bread.**—F. Keller(4) examined the nature of the acid in brown bread made with leaven. By distilling the infusion of the bread, he obtained a volatile acid which he recognized as acetic acid by the crystalline form of the soda-salt, and by the determination of its equivalent in the silver-salt. No lactic acid could be discovered in the residue of the distillation.—On this occasion Keller estimated the amount of nitrogen in rye bread, and found it to be 1.8 per cent; the amount of nitrogen in the portion insoluble in water he estimated as 1.31, and that in the soluble portion of the bread (with or without the crust?) as 0.37 per cent.

**Potatoes.**—The method for determining the amount of amylon (starch) in potatoes from their specific gravity, has been put into a

(1) J. Pharm. [3] XVIII, 47.

(2) Instit. 1850, 141; J. Pr. Chem. L, 363.

(3) From Bull. de l'Académie Royale des Sciences de Bruxelles in J. Pr. Chem. XLIX, 260.

(4) Repert. Pharm. [3] IV, 336.

potatoes.

practical form by Fresenius and Fr. Schulze(1), which can be executed by every experimenter, and which bids fair to secure to this question the attention it merits. They purpose, namely, to put a proper quantity of potatoes (from 6 to 12) into a concentrated solution of chloride of sodium, and then to dilute the solution with water until one portion of the potatoes has sunk to the bottom of the vessel whilst another portion is still floating. The dilute solution of the salt then possesses the average spec. grav. of the sample which is now determined by means of a hydrometer. Fresenius and Schulze have obtained results agreeing with experiments made by weighing potatoes in water.

**Manufacture of Sugar.**—Mulder(2) has made an extensive investigation with 13 different kinds of crude sugar from Java, in order to decide the question repeatedly raised in practice, whether sugar boiled down over an open fire possesses more sweetness than that manufactured by means of apparatus heated by steam as, for instance, that of Derosne and Cail, Howard and others). The result he arrived at is, that both kinds of sugar do not differ from each other in a greater degree than the various sorts of the same kind, either as regards the amount of water which they contain, or the amount of ashes, or the amount of admixtures insoluble in water, or the amount of grape- and cane-sugar, or lastly their solubility in alcohol.

The amount of grape-sugar in the above samples was very trifling, from 0.5 to 1.75 per cent; it was determined according to the method described p. 416 of this Report; the quantity of water in the air-dried samples amounted to somewhat more than 1 per cent, that of the ashes scarcely to more than traces. These values were of course still smaller with the far purer products, viz.: candy-, loaf- and lump-sugar, which were likewise examined(3). Mulder obtained in 100 parts of the air-dried substance:

|                     | Water at 100°. | Ash.           | Grape-sugar.   |
|---------------------|----------------|----------------|----------------|
| Of 5 sorts of candy | 0.011 to 0.475 | 0 to 0.104     | 0.132 to 0.192 |
| „ 4 „ loaf          | 0.071 to 0.100 | 0.03 to 0.735  | 0.134 to 0.239 |
| „ 4 „ lump-sugar    | 0.121 to 0.225 | 0.052 to 0.152 | 0.230 to 0.365 |

Payen, Poincot and Brunet(4) found in 100 parts of the molasses of beetroot-sugar (a), and Th. J. Herapath(5) in 100 parts of the sediment in the clarifying-coppers of sugar-refineries (b):

(1) J. Pr. Chem. LI, 436.

(2) From Scheikund. Onderzoek. V, 6. Stuk, 256, in Jahrb. Pr. Pharm. XX, 273.

(3) Scheikund. Onderzoek. V, 7. Stuk, 400.

(4) J. Pharm. [3] XVII., 48; J. Pr. Chem. L, 204; Dingl. Pol. J. CXV, 238.

(5) Chem. Soc. Qu. J. III, 367.

|                                                    | a.    | b.    |                                            | a.    | b.    | Manufacture of sugar. |
|----------------------------------------------------|-------|-------|--------------------------------------------|-------|-------|-----------------------|
|                                                    |       |       |                                            |       |       |                       |
| Water . . . . .                                    | 21.74 | 48.94 | Carbonate of lime . . . . .                | 0.874 | 3.964 |                       |
| Organic matter . . . . .                           | 65.68 | 37.49 | "    magnesi . . . . .                     | 0.118 |       |                       |
| Nitrogen . . . . .                                 | 1.47  | 1.41  | Sulphate of lime . . . . .                 | —     | 1.231 |                       |
| Carbonate of potassa . . . . .                     | 9.699 | 0.146 | Phosphate of lime and magnesia . . . . .   | —     | 2.679 |                       |
| "    soda . . . . .                                |       | —     | Phosphate of sesquioxide of iron . . . . . | —     | 1.320 |                       |
| Sulphate of potassa . . . . .                      | 0.280 | —     | Silica . . . . .                           | 0.009 | —     |                       |
| "    soda . . . . .                                | —     | 0.155 | Alumina, sesquioxide of iron . . . . .     | 0.021 | —     |                       |
| Chloride of sodium & chlor. of potassium . . . . . | 1.578 | 0.237 | Sand . . . . .                             | —     | 3.842 |                       |

**Use of Carbonic Acid.**—Kuhlmann(1) proposed (in the year 1838), as is well known, to make a more extensive use of the very favourable properties of quicklime in the clarification of the juice of beetroot, by adding an increased quantity of that substance and by separating the excess again, at the proper moment, by means of carbonic acid. By this mode of proceeding, he had a double purpose in view: on the one hand, a more lasting protection of the sugar from decomposition, and a more complete separation of the foreign, especially the albuminous substances; on the other hand, a saving in the most expensive factor of the manufacture of sugar, viz.: animal charcoal. The special method by which Kuhlmann then intended to introduce his idea into practice was, however, little calculated to answer the above purpose, because—according to the Report to be mentioned forthwith—he did not *immediately* separate the greater portion of the precipitate formed during the process of clarification, but only after the lime was precipitated by carbonic acid, viz.: after the first period of evaporation. The juice was thus exposed at a boiling heat to the injurious contact with those bodies, and the precipitates were towards the end partly redissolved by the carbonic acid (during the separation of the lime).

After a lapse of ten years, Rousseau(2) has resumed the proposal of Kuhlmann, and has given it a practical form which answers the requirements of the manufacturer, according to the Report of the Committee(3) elected by the French Academy for the purpose of inquiring into this subject. By this method the clarification is effected (according to the quality of the beetroot) with a quantity of lime 3 to 4 times as large as that hitherto used—a quantity of lime which should be about sufficient to convert all the sugar present into sugar-lime. As soon as the juice has reached the temperature of 55°, the lime is added, previously mixed with 6 times its quantity of water; the temperature is now raised to 88° or 90°, the steam then

(1) Ann. Chem. Pharm. XXVII, 17.

(2) A description by Payen of the method and the apparatus, Instit. 1850, 330, next in Bull. Soc. d'Encouragement, Mars, 1850, 132 (thence in Dingl. Pol. J. CXVI, 297); notes on the results obtained by experiments in manufacturing, likewise by Payen, Moniteur Industr. 1850, No. 1425 (thence in Dingl. Pol. J. CXV, 457).

(3) Compt. Rend. XXXI, 539; Instit. 1850, 330; Dingl. Pol. J. CXVIII, 221.



Use of  
carbonic  
acid.

shut off (consequently before the juice begins to boil), the precipitate allowed to settle, and the liquor passed through a filter. The juice, now perfectly clear, is then treated with carbonic acid without delay. At first a bulky froth is formed, which goes down as the precipitation of the lime from the sugar-compound progresses, and disappears entirely towards the end; the carbonic acid is then shut off, and the juice, after being previously deprived of the excess of carbonic acid by boiling, brought on a charcoal-filter. It is not required to let the lime first settle. The filtered liquor is then farther treated as usual, and is said to yield very satisfactory products, which can be worked up with facility. The Commission of the Academy consider that the method of Rousseau—provided the sugar in the precipitates is properly recovered—is more economical than the ordinary one; they are, however, of opinion that the alkalies in the juice which remain behind in the form of carbonates after the treatment with carbonic acid, might exercise an unfavourable influence by acting on the foreign organic substances not precipitated by the lime. They state, however, farther, that Rousseau has also provided a remedy against this, by advising the addition, towards the end of the action of the carbonic acid, of some ammonia which, in the form of carbonate of ammonia, decomposes the compounds of those organic substances with lime, when the lime is precipitated, the ammonia set free, and the organic substance transferred to the alkali which is thus neutralized. Taking this as granted, still the organic substances in the last-named compound will remain dissolved, and will be decomposed during the boiling, and thus give rise to colour; the same evil is therefore again encountered, the removal of which formed the starting-point.

Michaelis(1) has described an apparatus for the purpose of separating the lime from the clarified juice by means of carbonic acid; Payen(2) has also communicated such an apparatus, which is at the same time constructed to prepare carbonic acid from coke.

Kuhlmann(3) has likewise, recently made some experiments and observations on the manufacture of sugar from beetroot, which partly have reference to his former proposals on this branch of industry, partly have for their object to test new methods discovered by him.—His experiments confirm, first, the decidedly favourable influence which is exerted by an excess of lime employed in the clarification, acting as a preservative against the changes of the juice; they farther show, that this excess, however varying its amount may be, can at all times be removed by the addition of carbonic acid, with the exception of a slight remnant, which is, however, pretty constant.—Kuhlmann

(1) Dingl. Pol. J. CXV, 444.

(2) Rev. Scientif. Industr. XXXVIII, 219.

(3) Compt. Rend. XXX, 341; Instit. 1850, 154; Dingl. Pol. J. CXVI, 61.

regards, as a principal evil in the clarification with lime, that potassa and soda become free, the alkaline reaction of which is not neutralized by the subsequent process. His endeavours to remove the alkalis by a proper agent were at first unsuccessful. The application of the ordinary mineral acids proved perfectly unpracticable on account of the necessity and difficulty of neutralizing them exactly. The alkalis do not act upon sulphate of magnesia in the presence of sugar.

**Use of Phosphate of Ammonia.**—Kuhlmann, therefore, relinquished the salts with fixed bases and directed his attention to those with a volatile base, viz.: the ammonia-salts; he thus found that sal-amoniac and sulphate of ammonia offered considerable impediments, that however the addition to the juice of 1 per cent of phosphate of ammonia proved advantageous, inasmuch as it precipitates at the same time the excess of lime in the sugar and neutralizes the alkalis, as well as imparts to the juice thus treated excellent properties during the boiling, which render it applicable on the large scale. A trial made on the large scale proved very successful. Respecting the price of this salt, Kuhlmann is of opinion that it could be procured at a sufficiently cheap rate when made the subject of a regular manufacture on the large scale.

**Use of Acetate of Lead.**—Scoffren(1) published some statements on the Spanish manufacture of cane-sugar, and mentions on this occasion that he introduced there, with complete success, his method of clarifying sugar by means of basic acetate of lead and sulphurous acid (see Annual Report for 1847 and 1848, II, 344, and for 1849, III, 494).—The specification of Scoffren's patent(2), which has since been published, gives some account of the manipulations necessary for its application. From this it is seen, that the lead-salt is only added to the juice after this has been kept boiling for some time, after the coagulated mass thus formed has been removed, and the skimmed liquor been cooled down a few degrees below the boiling-point. The application of the lead-salt in this method has recently caused some anxiety on account of the poisonous properties of the products if the latter should contain an amount of lead. An official inquiry on this subject has been undertaken by Thos. Graham, Thos. Thomson, and A. W. Hofmann(3); they state that an amount of lead could certainly be detected in the products (loaf and syrup), but that this amount occurs likewise in the products of the former methods, and although it was in every instance below the really dangerous quantity, yet it ought not to escape the serious consideration of the authorities. Three medical arbitrators, Pereira, A. S. Taylor and Carpenter(4) declared, in

(1) Chem. Gaz. 1850, 340; Instit. 1850, 335; Dingl. Pol. J. CXVIII, 217.

(2) Chem. Gaz. 1850, 368.

(3) Pharm. J. Trans. X, 180.

(4) Ibid. 184.

Use of  
acetate of  
lead.

answer to a similar question put to them, that the amount of lead found by the above chemists was, at least in the molasses, sufficiently large to interdict its use as a daily article of food.—Physiological experiments on this subject made by Gregory(1) on animals, appeared to prove to him the perfect harmlessness of sulphite of lead.—Brande(2) coincides with this view; he points out the complete insolubility of this salt, and directs attention especially to the state of the protoxide of lead. He observes that in ordinary syrup the protoxide of lead in paint taken in the form of carbonate, and is, therefore, 'injurious'; but this is not the case with the sulphite in the new method. Scoffren(3) defends his method by means of the arguments brought forward by Brande and Gregory; Redwood(4) proves, however, that sulphite of lead can be dissolved by means of small quantities of hydrochloric and lactic acids, as well as by chloride of sodium, and indirectly by soda.

**Use of Sulphate of Binoxide of Tin.**—In a letter to Graham(5) Wardlawton discusses some experiments which he has instituted for the purpose of testing the capability of the salts of the heavy metallic oxides for decolorizing sugar-syrups in manufactures. Without arriving at definite results, he found on this occasion that basic acetate of lead, although it yields good results, is far less active than sulphate of tin if this be added to the saccharine juice with an excess of lime and then be heated to boiling. The precipitate is said to be a mixture of gypsum and of the compound of the organic matter with binoxide of tin.

**Use of Baryta.**—The methods hitherto used or proposed for the separation of the sugar from the juice of the beetroot and of the sugar-cane, are based upon the transformation of the foreign substances into an insoluble form or combination, consequently upon a separation of these substances from the sugar. The reverse, viz. : the separation of the sugar from the foreign bodies by a precipitation of the former from the juice, is arrived at by the method of Dubrunfaut and R. de Massy, for which a patent has recently been taken out in France. It is based on the well-known property of baryta to form an insoluble compound with the sugar at a boiling-point.—Gaultier de Claubry(6) published the following communication on the method in question. The juice is mixed with so much caustic baryta as is required to precipitate the whole of the sugar; the precipitate formed is separated from the liquor which retains all the other substances in solution, by washing, and by means of appropriate mechanical contrivances (replacement-apparatus, &c.); it then forms pure sugar-baryta which is next decomposed by means of carbonic or sulphuric acids.

(1) Pharm. J. Trans. X, 187.

(3) Ibid. 189.

(5) Chem. Soc. Qu. J. III, 55.

(2) Ibid. 188.

(4) Ibid. 120; Chem. Gaz. 1850, 438.

(6) J. Pharm. [3] XVII, 379.

On the one hand, a solution of pure sugar is obtained, which is boiled down as usual; and on the other hand, carbonate or sulphate of baryta which are again worked up for caustic baryta; the former by ignition with charcoal, the latter by being converted into sulphide of barium which is again decomposed by protoxide of copper.—It is very doubtful whether caustic baryta possesses in reality the property of leaving in solution all the substances which accompany the sugar. Moreover, in the specification of this patent taken out in England under the name of Newton(1) it is especially required that the treatment with baryta is to be applied only after the usual clarification with lime.

**Use of Ammonia.**—Michaclis(2) thinks he has materially improved the manufacture of the sugar from beet-root by proposing to add ammonia to the fresh pulp of the beet-root; however, as he himself remarked, he has obtained but little encouragement from the manufacturers.

Barreswill(3) has published a short critical synopsis of the more important recent methods for manufacturing sugar; it is the introduction to a more extensive analytical inquiry into this subject, which he has in view.

Scharling(4) convinced himself by experiment, that the decolorizing power of the animal charcoal used in sugar-factories, may be restored to it by treatment with overheated steam, quite as effectually as by the usual process, that, however, it is thus apt to retain a portion of the absorbed substances which are injurious to the purity of the sugar.

**Extraction of Cane-juice.**—Payen(5) described a machine invented by Bessemer for the purpose of extracting the juice from the canes.

**Beer.**—In a treatise on the composition of beer, Wackenroder(6) published a series of analyses made in 1846 and in 1849, from which we extract the following particulars: whenever the same beer was analyzed twice, only the later analysis of the two is given. Nos 1 to 4 inclusive are beers brewed for stock, viz.: No. 1, of the Royal Brewery at Munich; No. 2, of the Rose Brewery at Jena; No. 3, of the Municipal Brewery at Jena; No. 4, from Oberweimar. The others are ordinary beers, viz.: No. 5, from the Rose Brewery at Jena; No. 6, from the same place, (*Doppelbier*, double or strong beer); No. 7, from Lichtenhain; No. 8, from Ziegenhain; No. 9, from Wöllnitz (the last three were foul).

(1) From London Journal of Arts, May, 1850, 229 in Dingl. Pol. J. CXVII, 136.

(2) Dingl. Pol. J. CXV, 451.

(3) J. Pharm. [3] XVII, 351; J. Pr. Chem. L, 269.

(4) J. Pr. Chem. L, 375.

(5) Compt. Rend. XXXI, 780.

(6) De Cerevisiæ vera Mixtione et Indole Chemica; Jenæ, 1850.

Beer.

| Number . . .                  | 1.      | 2.      | 3.      | 4.      | 5.      | 6.      | 7.      | 8.      | 9.      |
|-------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Alcohol . . .                 | 4.019   | 3.541   | 2.895   | 3.641   | 2.083   | 1.880   | 2.871   | 2.566   | 2.433   |
| Albumin . . .                 | 0.023   | 0.019   | 0.016   | 0.019   | 0.005   | 0.070   | 0.043   | 0.078   | 0.023   |
| Dextrin . . .                 | 6.193   | 4.754   | 7.852   | 5.357   | 7.707   | 4.804   | 4.891   | 5.544   |         |
| Sugar . . .                   | 0.351   | 0.394   | 0.292   | 0.203   | 0.304   | 0.386   | 0.295   |         |         |
| Lactic acid . . .             | 0.202   | 0.148   | ?       | ?       | 0.103   | ?       | 0.707   | 0.347   | 0.407   |
| Water and carbonic acid . . . | 89.212  | 91.538  | 88.843  | 90.691  | 93.604  | 90.039  | 91.109  | 91.823  | 93.593  |
|                               | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |

The alcohol was determined by distillation. It is necessary farther to state that Wackenroder designates as *albumin*, all that which coagulates when the beer is boiled (in Nos. 7, 8, and 9, the suspended particles causing the cloudiness are included); as *sugar*, that portion which is dissolved by alcohol from the (not completely dried) extract left on evaporation; and as *dextrin*, whatever is thus left undissolved. The residue obtained on evaporating the alcohol (sugar) yielded to ether minute quantities (0.005 to 0.013) of oily, fatty, and resinous substances. According to Wackenroder, all beers contain a non-volatile acid, free, which he regards as lactic acid, although he did not succeed in obtaining a crystalline zinc-salt from it. The light beers made by the top-fermentation (*Obergährung*) contain more of it than the stock beers, brewed by the bottom-fermentation (*Untergährung*); it also occurs, in some instances, even in the wort. The lactic acid mentioned has been determined by the acidimetric method by means of a standard solution of carbonate of potassa, either in the beer itself, previously coloured with Brazil-wood, or, when the beer contained acetic acid, in the extract. The estimation of the ammonia, which was attempted by distilling the beer with lime, cannot quite be depended upon. In conclusion, Wackenroder thinks, contrary to the opinion prevailing at the present time, that in the fermentation of beer there is certainly a formation of a kind of fusel-oil, and he suspects that one of the substances extracted from the *sugar* by means of ether is cœnanthylic acid; which, however, he did not succeed in demonstrating in a direct manner.

Engelmann(1) communicates the following analyses of beers from Wiesbaden [Nos. 1 to 4, inclusive, strong beer (*Doppelbier*); No. 5, light beer (*Dünnbier*)], which he executed for the purpose of comparing the various methods of examining beer. (*B* signifies Balling's saccharimetric, *St* Steinheil's optical and hydrometric method, *Fh* Fehling's mode of determining sugar, *dst* direct determination of alcohol by means of distillation).

| No. | Extract      |              |      | Sugar in the beer. | attenuated sugar. | Amount of alcohol. |       |      |      |
|-----|--------------|--------------|------|--------------------|-------------------|--------------------|-------|------|------|
|     | of the wort. | of the beer. |      |                    |                   | calculated from e. | B.    | St.  | dst. |
|     | B.           | St.          |      |                    |                   |                    |       |      |      |
|     | Ph.          |              |      |                    |                   |                    |       |      |      |
| 1   | 14.942       | 6.487        | 6.40 | 1.111              | 8.455             | 4.32               | 4.416 | 4.30 | 4.23 |
| " 2 | 12.359       | 6.122        | 6.20 | 1.000              | 6.237             | 3.18               | 3.229 | 3.20 | 3.06 |
| " 3 | 11.409       | 4.375        | 4.50 | 0.741              | 7.134             | 3.59               | 3.623 | 3.60 | 3.49 |
| " 4 | 11.302       | 5.025        | 5.10 | 1.000              | 6.277             | 3.20               | 3.231 | 3.10 | 3.14 |
| " 5 | 10.861       | 5.125        | —    | 1.910              | 5.736             | 2.93               | 2.946 | —    | 2.86 |
|     | a            | b            | c    | d                  | e                 | f                  | g     | h    | i    |

Beer.

The quantity of sugar attenuated during the fermentation is inferred from the difference of the amount of extract in the wort and in the beer. The quantity of alcohol which, according to calculation, should thus be formed agrees, as will be seen, very closely with that found by experiment.

Walz(1) has analyzed 13 different kinds of beer. Considering the total omission of all details respecting the properties and the mode of brewing of these beers, the numbers obtained by Walz offer too little interest to be inserted here.

**Fuel and Illuminating Materials. Illumination by Gas.**—For the purpose of purifying *coal gas*, Laming(2) recommends the application of a saturated solution of sesquichloride of iron, mixed with lime: this is mixed with sawdust in order to convert it into a moist, permeable mass. The advantage of this mixture is said to consist in the following property; after being used—consequently, after the absorption of sulphuretted hydrogen—it can be regenerated by mere exposure to the atmosphere, and thus be rendered capable of being applied afresh, until at last it becomes unfit by too great an accumulation of ammonia-salts.—Besides Laming, Hills(3) has likewise taken out a patent for this method.

Malenfant(4) found, in testing the ammoniacal liquor of the gas-works at Chalons-sur-Marne by the alkalimetical method, that 1 litre neutralized a quantity of sulphuric acid corresponding to 24.7 grms. of ammonia. He farther states that he found sulphocyanide of calcium in the aqueous extract of the lime from the purifiers of the gas.

**Manufacture of Stearin.**—Scharling(5) proposes to effect the decomposition of fats for the purpose of manufacturing stearin by

(1) Jahrb. Pr. Pharm. XX, 149.

(2) From Lond. Journ. of Arts, May, 1850, 279 in Dingl. Pol. J. CXVI, 294; Chem. Gaz. 1850, 218.

(3) From Lond. Journ. of Arts, August, 1850, 26 in Dingl. Pol. J. CXVIII, 102.

(4) J. Pharm. [3] XVIII, 131. (5) Loc. cit. p. 275.

Manufac-  
ture of  
stearin.

means of over-heated steam. This method has been practically applied for several years already; see the patent of G. Gwynne and G. Wilson(1).

A communication in the *Journal de Chimie Médicale*(2) recommends the application of oxalic acid, in the proportion of  $\frac{1}{1000}$ , for the purpose of bleaching stearic acid. The bleaching agent should be added in solution to the stearic acid, melted as usual by steam, and should be boiled with it during a quarter of an hour. The operation is apt to fail when the stearic acid has previously been treated with albumen, as is frequently done. When stearin thus bleached is exposed for some time to the air, a foreign substance is separated by oxydation. In order to remove this substance, and at the same time the oxalic acid still adhering, the stearin should be melted with water acidulated with sulphuric acid, then mixed with 10 per cent of white wax, and agitated with a solution of white of eggs (2 eggs for every 50 kilgrms. of stearin), until the melted fat appears transparent.

**Use of Hydrogen as Fuel and Illuminating Material.**—From a report of O. Henry(3), we learn the following particulars on the manufacture and application of hydrogen for illuminating and heating purposes, which has been for some time carried on in an establishment at Passy, near Paris. The principle on which it was at first based by the inventor, Gillard, consisted in a reduction of the vapour of water in a red-hot gas retort filled with iron-wire; connected, however, with a contrivance which rendered it possible to restore the efficiency of the wire which had become oxydized, and was thus rendered inert. By the mere turning of a two-way cock, namely, the access of the steam was shut off, and a current of carbonic oxide (disengaged for this purpose from coke) admitted into the retort. Carbonic acid was thus formed, which was not conducted to the hydrogen, but into a separate channel, and the metallic iron, after the original communication of the cock was restored, served again for the disengagement of hydrogen, and so on, in uninterrupted succession. Various difficulties, however, induced Gillard to abandon this system, and to replace it by another in which the decomposition of the steam was effected by passing it through a retort filled with red-hot charcoal. The gas disengaged by this process generally consists, as is well known, of about 4 vols. of hydrogen, 1 vol. of carbonic acid, and 2 vols. of carbonic oxide, which latter amount may certainly be diminished by an excess of steam. Gillard, however, no doubt is mistaken if he expects to obtain a mixture of hydrogen and carbonic acid (which he separates by an ordinary lime-purifier) free from carbonic oxide.

(1) *Dingl. Pol. J. C.*, 472.

(2) *J. Chim. Méd.* [3] VI, 69.

(3) *J. Pharm.* [3] XVII, 105; *Dingl. Pol. J.* CXVI, 222.





# ANALYSES OF VARIOUS KINDS OF FUEL.

[TO FACE PAGE 469.]

(E.)

| No.          |                                          | Fresh from the mine.          |             | Dried.   |            | Percentage.           |       |              |
|--------------|------------------------------------------|-------------------------------|-------------|----------|------------|-----------------------|-------|--------------|
|              |                                          | Amount of water in per cents. | Spec. grav. | Car-bon. | Hydro-gen. | Oxygen and ni-trogen. | Ash.  |              |
| BROWN COALS. |                                          |                               |             |          |            |                       |       |              |
| 1            | Riestedt; Georgengrube, in pieces        | 33.4                          | 1.197       | 57.13    | 4.16       | 27.05                 | 11.66 | F. Bischoff. |
| 2            | " fossil wood                            | 31.7                          | 1.218       | 61.13    | 5.09       | 31.95                 | 1.83  |              |
| 3            | Voigtstedt; earthy, with fossil wood     | 40.2                          | 1.241       | 49.15    | 4.45       | 32.25                 | 14.15 |              |
| 4            | Löderburg; earthy, clear                 | 49.5                          | 1.219       | 45.30    | 4.90       | 31.95                 | 7.85  |              |
| 5            | Mertendorf; earthy, clear                | 48.6                          | 1.233       | 49.45    | 5.17       | 24.84                 | 21.54 |              |
| 6            | Altenweddingen; earthy, with nodules     | 47.3                          | 1.194       | 57.71    | 4.75       | 22.94                 | 14.60 |              |
| 7            | Biere; earthy, with nodules              | 46.9                          | 1.200       | 55.92    | 4.77       | 22.48                 | 16.83 |              |
| 8            | Tollwitz; earthy, clear                  | 49.6                          | 1.257       | 57.51    | 5.29       | 25.40                 | 11.80 |              |
| 9            | Pretzsch; earthy, with nodules           | 50.7                          | 1.213       | 50.80    | 4.96       | 26.20                 | 18.04 |              |
| 10           | Tenditz; earthy, clear                   | 48.6                          | 1.263       | 54.02    | 5.28       | 27.90                 | 12.80 |              |
| 11           | Brumby; earthy, with pieces              | 40.6                          | 1.263       | 47.78    | 4.28       | 18.42                 | 29.52 |              |
| 12           | Lebendorf; earthy, with pieces           | 42.7                          | 1.318       | 47.73    | 4.34       | 17.64                 | 30.29 |              |
| 13           | Zscherben; earthy, with nodules          | 49.5                          | 1.207       | 57.82    | 5.59       | 24.53                 | 12.06 |              |
| 14           | Runthal; upper mine, earthy, clear       | 50.0                          | 1.139       | 59.35    | 5.86       | 26.31                 | 8.48  |              |
| 15           | Runthal; lower mine, earthy, clear       | 48.7                          | 1.127       | 65.94    | 6.07       | 25.67                 | 2.32  |              |
| 16           | Wörschen; earthy, clear                  | 49.9                          | 1.142       | 60.76    | 5.39       | 23.13                 | 10.12 |              |
| 17           | Görstewitz; earthy, with pieces          | ..                            | ..          | 67.11    | 10.28      | 10.02                 | 12.59 |              |
| 18           | Rauen's Förderkohle                      | 14.83                         | ..          | 59.00    | 4.55       | 25.77                 | 10.68 |              |
| ROCK COALS.  |                                          |                               |             |          |            |                       |       |              |
| 19           | Leopoldgrube                             | 3.55                          | ..          | 76.21    | 5.03       | 13.50                 | 5.26  | W. Baer.     |
| 20           | Faustagrube, Claraflötz                  | 3.75                          | ..          | 76.63    | 4.98       | 13.92                 | 4.47  |              |
| 21           | " Faustflötz                             | 3.84                          | ..          | 77.25    | 4.58       | 13.35                 | 4.82  |              |
| 22           | Königsgrube, Gerhardflötz                | 4.15                          | ..          | 79.51    | 4.87       | 12.96                 | 2.66  |              |
| 23           | " Heintzmannflötz                        | 4.37                          | ..          | 73.48    | 4.95       | 18.64                 | 2.93  |              |
| 24           | Silesian. Mine Morgenroth                | 8.35                          | ..          | 74.57    | 4.82       | 16.14                 | 4.47  |              |
| 25           | " Leo                                    | 4.06                          | ..          | 78.22    | 4.89       | 12.95                 | 3.94  |              |
| 26           | " Louise, Oberflötz                      | 3.81                          | ..          | 76.02    | 4.99       | 14.87                 | 10.12 |              |
| 27           | " " Niederflötz                          | 3.27                          | ..          | 70.79    | 5.32       | 19.34                 | 4.55  |              |
| 28           | " Eugeniens Glück                        | 6.83                          | ..          | 73.20    | 4.93       | 19.11                 | 2.76  |              |
| 29           | " Glückhelf                              | 2.39                          | ..          | 80.82    | 5.10       | 9.51                  | 4.57  |              |
| 30           | König. Louisengr. Heintzflötz            | 3.35                          | ..          | 73.91    | 4.85       | 17.59                 | 3.65  |              |
| 31           | Mine Laura                               | 1.05                          | ..          | 74.81    | 4.35       | 8.76                  | 12.08 |              |
| 32           | " Glücksburg Flötz Franz                 | 1.28                          | ..          | 72.66    | 4.05       | 9.24                  | 14.05 |              |
| 33           | " " Flötz Flottwell                      | 1.08                          | ..          | 77.25    | 4.02       | 8.14                  | 10.59 |              |
| 34           | " of Engelsburg                          | 1.23                          | ..          | 85.90    | 4.56       | 6.33                  | 3.21  |              |
| 35           | West-phalian. " Schafberg, Fl. Alexander | 1.27                          | ..          | 82.02    | 4.16       | 4.53                  | 9.29  |              |
| 36           | " Bower mine Franziska                   | 1.19                          | ..          | 77.10    | 4.55       | 11.79                 | 6.56  |              |
| 37           | " Louise                                 | 2.25                          | ..          | 78.05    | 5.05       | 12.92                 | 3.98  |              |
| 38           | " Mine Präsident                         | 1.31                          | ..          | 79.72    | 4.62       | 12.40                 | 3.26  |              |
| 39           | " Friedrich Wilhelm                      | 2.03                          | ..          | 82.22    | 5.00       | 7.71                  | 5.07  |              |
| ANTHRACITE.  |                                          |                               |             |          |            |                       |       |              |
| 40           | Calton Hill                              | ..                            | ..          | 91.23    | 2.91       | 5.86                  | ..    | Völcker.     |
| COKE.        |                                          |                               |             |          |            |                       |       |              |
| 41           | From coal of the Faustflötz              | 4.96                          | ..          | 87.82    | 1.43       | 5.14                  | 5.61  | Baer.        |
| 42           | " " Gerhardflötz                         | 5.88                          | ..          | 90.01    | 1.46       | 6.30                  | 2.23  |              |
| 43           | PEAT-COAL                                | 5.28                          | ..          | 78.42    | 4.01       | 14.77                 | 2.80  |              |

For the purpose of illumination, the gas is to be mixed with a proper amount of atmospheric air, and a cylinder of fine platinum-wire introduced into the flame, when by the ignition of the former the light is produced. According to experiments made with this gas at Manchester by Hodgett(1), its illuminating power is only half as great as that of the gas from cannel-coal; it requires, therefore, more spacious apparatus and pipes, and is besides expensive on account of the large amount of lime required, and the want of useful secondary products.

Use of  
hydrogen  
as fuel and  
illuminat-  
ing mate-  
rial.

According to the above report, Gillard(2) finds his gas particularly applicable to the heating of rooms, because all the heat disengaged remains in the heated space; he does not state, however, in what manner this is to be done.

**Anthracite.**—In the anthracite of Calton Hill, near Edinburgh, Völcker(3) found 0.59 per cent of nitrogen, 2.96 of sulphur, and 1.05 of ashes, in addition to the amount of carbon and hydrogen given in table E, No. 40. He draws attention to the large amount of sulphur, which amounted to far more than the iron could take, even if the ash consisted entirely of sesquioxide of iron. He supposes that the sulphur is contained in the anthracite as a constituent of an organic compound.—According to Horsford(4), the ash of the anthracite of Lehigh (North America) contains 0.5 per cent of soda but no potassa.

**Coal.**—W. R. Johnson(5) has compared the American coals (according to former investigations) with those of Great Britain (after Playfair and de la Beche, Annual Report for 1847 and 1848, II, p. 353 *sqq.*, and for 1849, III, 497).

In continuation of the investigation of various kinds of fuel by W. Baer(6) (see Annual Report for 1847 and 1848, II, p. 350), a second and a third series have now been published, the results of which are contained in table E, No. 19 to 39 incl., and 41 to 43 incl. The amount of water was determined by drying at 100°, the carbon—in order to avoid errors resulting from the formation of sulphurous acid—by combustion with a mixture of the protoxides of copper and lead; the nitrogen, partly by the method of Dumas, partly by that of Will and Varrentrapp. The latter amounted in the coal of the mine of the Engelsburg to 1.56 per cent (determined by Dumas' method), in that of the Königin Louise Mine from Heinitzflötz to 2.49, and in that of the Mine President to 0.84 per cent (both determined by Will and Varrentrapp's method). From the quantitative

(1) From Journal of Gas-lighting, in Dingl. Pol. J. CXVIII, 156.

(2) Loc. cit. p. 468.

(3) Proceed. of the Roy. Soc. of Edinburgh, 1850, 300; Edinb. New Phil. Journ. XLVIII, 333; Instit. 1850, 285.

(4) Proceed. of the Americ. Assoc. held at Cambridge, 1849, 233.

(5) Ibid. 221.

(6) Arch. Pharm. [2] LXI, 1; and LXIII, 129.

**Coal.** analysis of the ashes of the coals, it appears that all the kinds examined contain sesquioxide of iron, alumina, lime, silica, sulphuric acid, and sulphur in large quantities; baryta (in those of Silesia only), magnesia, chlorine, and phosphoric acid in more minute quantities.—According to a correction of Baer, the brown coal mentioned in the Annual Report for 1847 and 1848, II, p. 350, is not from *Plauen*, but from *Rauen*, in the neighbourhood of Fürstenwalde.

**Brown Coal.**—F. Bischoff(1) has made an investigation of the brown coal occurring in the Prussian province of Saxony; the results are communicated in table E, No. 1 to 18 incl. The brown coal of Voigtstedt and of Riestedt possesses a distinct ligneous structure; the others are earthy. The colour is, in the order observed in the table, from black (Riestadt), to light brown (Runthal), and yellow (Görstewitz). The large amount of water in the fresh coal is said to be reduced only to 25 or 30 per cent by drying in the air. During this process, however, no increase of the value as fuel takes place; but a diminution of it in consequence of a decomposition not as yet more closely investigated ("cold combustion"). On account of this propensity to undergo decomposition, the analyzed samples have been dried at a temperature not quite reaching the boiling-point. We omit the theoretical values of their heating power calculated by Bischoff from his experiments, since this kind of calculations is based on suppositions which, according to recent observations (see Annual Report for 1847 and 1848, I, p. 34, *sqq*), cannot now be regarded as correct.

**Peat.**—Soubeiran(2) obtained by the ultimate analysis of peat occurring near Menucny in the neighbourhood of Corbeil, 54.6 per cent of carbon, and 5.44 per cent of hydrogen. After washing the peat with hot alcohol and with ether, he obtained 53.5 per cent of carbon, 5.40 of hydrogen, 2.1 of nitrogen, and 38.7 of oxygen, the amount of ashes (not stated) being deducted.

Petzholdt(3) gives an account of a fossil, applicable as fuel, which occurs on the northern shore of the Peipus Lake in Esthland, as a member of the silurian mountain. This fossil forms a stratified, light-brown, friable mass consisting, according to Petzholdt, of 65.5 per cent of organic matter, 33.1 per cent of ash and 1.2 per cent of moisture, and surpassing wood in heating power.

**Coke.**—A most important improvement in the manufacture of coke has met with an extensive application in France during the last ten years. It consists in freeing the coal intended for the manufacture of coke, from adhering minerals (iron pyrites), by means of a mechanical preparation in the moist way; a considerable diminution in the amount of ashes and a corresponding increase of the value

(1) From the *Bergwerksfreund* Bd. XIII, No. 23 in *Dingl. Pol. J.* CXVI, 103.

(2) *J. Pharm.* [3] XVIII, 16; *J. Pr. Chem.* L, 291; *Dingl. Pol. J.* CXVII, 383.

(3) *J. Pr. Chem.* LI, 112.

of the coke is thus effected. Marsilly(1) has now published a long description of an improved method for doing this, concerning which we refer to the original.

Pyrolig-  
neous  
acid.

**Pyroligneous Acid.**—The experience in the manufacture of pyroligneous acid has shown that the pyrolignite (acetate) of lime is in no instance completely decomposed by Glauber's-salt, and that at the same time a portion of the precipitant is thrown down with the sulphate of lime in the form of a compound, very little soluble in water. According to Beringer(2), a manufacturer in Berlin has succeeded in avoiding this double loss, and in obtaining a very pure acetic acid, by immediate saturation of the crude pyroligneous acid with sulphide of sodium.

**Application of Woody Fibre; Dyeing. Distinction of Various Woody Fibres.**—Maumené(3) employs the action of bichloride of tin on the carbo-hydrates (see p. 415 of this Report) to distinguish the animal textile fabrics from cotton and linen. On treating the fabrics with bichloride of tin at a temperature between 130° and 150°, the linen and cotton fibres become black, whilst the fibres of wool and silk remain unchanged. Of course this test is only applicable for light-coloured or white fabrics (yarn).

**Application of Casein in Dyeing.**—Broquette(4), who formerly introduced the application of albumen into the art of calico-printing, has given a new direction to this branch of industry by the application of animal substances for the purpose of fixing colours, an idea which promises to produce a lasting effect. By this treatment, the cotton is said to be "animalized"—viz.: prepared in such a manner that it behaves towards dyes like wool. The substance used by Broquette is prepared either from milk or from flesh. In the first case, the curd is separated from skimmed, sour milk, then carefully washed and dried. In the second case, minced meat is washed with water until it has become a white mass; this is dissolved in a weak solution of potassa, not to be used in excess, the warm solution strained, and then precipitated with an acid; the precipitate is treated as above.—The animal substance thus obtained is only the raw material for the actual fixing material. In order to prepare this, the dried substance is dissolved in water by means of caustic ammonia and heat; the solution is then mixed with 3 per cent of olive-oil and slaked lime, keeping it stirred so as to form a mass similar to an emulsion. This mass serves either as mordant (in which case it contains 13 per cent of lime), and is fixed upon the bleached calico.

(1) Ann. Min. [4] XVII, 381.

(2) Ann. Ch. Pharm. LXXIV, 345; Dingl. Pol. J. CXVII, 367.

(3) Compt. Rend. XXX, 447; Instit. 1850, 122; Dingl. Pol. J. CXVI, 325.

(4) From Rep. Pat. Invent. in Dingl. Pol. J. CXV, 66.

Applica-  
tion of  
casein in  
dyeing.

by steam, when it is ready for being dyed in the vats; or it is used to prepare printing colours. For the latter purpose, the mixture (prepared with 3 per cent of lime only), is triturated with the insoluble dye—for instance, ultramarine; this is then printed on the stuff, and fixed like steam-colours. Vegetable pigments are first converted into lakes, and then treated in the same manner.

Barreswil(1) has published a description of Broquette's method with special references as to theoretical and practical details.

R. Wagner(2) obtained by Broquette's method with fustic on calico at first a fine colour, which afterwards changed considerably into brown, and generally he obtained unsatisfactory results.

**Deposition of Sal-ammoniac in Dyes containing Copper.**—In calico printing, in certain cases, especially with printing colours, the dyes are mixed with a salt of protoxide of copper and sal-ammoniac for the purpose of effecting oxydation. To explain the part which the latter plays in this process, C. Köchlin and Plessy(3) direct attention to the fact, that a solution of acetate of copper is not reduced by metallic copper when by itself, but in the presence of sal-ammoniac, and that the solution again assumes a blue colour when exposed to the air. In experiments made on this subject, they found that in dyeing with catechu, a solution of acetate of copper thus reduced, completely replaces the salts of protoxide of copper hitherto employed, which are not reduced; they explain this by the great facility with which the former solution absorbs oxygen from the air and yields it up again. They farther found, that sal-ammoniac cannot be replaced by another ammonia-salt but by chloride of sodium and other chlorides; and that the copper when employed in the form of chloride is very effective in the dyeing mixture, whilst it is almost entirely ineffective when used in the form of sulphate. Accordingly, they farther conclude, the advantage of the sal-ammoniac consists solely in the formation of protochloride of copper, for which purpose chloride of sodium is just as applicable; protochloride of copper behaves towards the pigment just as towards metallic copper in the above experiments, viz.: it oxydizes it lastingly, inasmuch as when reduced, it again absorbs oxygen, which it yields up again, and so on.

H. Schlumberger(4), in repeating these experiments, arrived at different conclusions. According to him, the sal-ammoniac rather effects the formation of double salts which, although they are intended to oxydize the colouring matters, are likewise destined to part with an oxide of copper for the purpose of fixing the dye upon the fibre; the sal-ammoniac, he says, can by no means be replaced by

(1) J. Pharm. [3] XVII, 271; J. Pr. Chem. C, 314; Dingl. Pol. J. CXVI, 227; Chem. Gaz. 1850, 384.

(2) Loc. cit. p. 358.

(3) J. Pharm. [3] XVIII, 401; J. Pr. Chem. LI, 474.

(4) J. Pharm. [3] XVIII, 406; J. Pr. Chem. LI, 279.

other chlorides. Protochloride and nitrate of copper have to be applied in too large a quantity, and are, therefore, not suitable. This he says is not merely the case when dyeing with catechu, but also with log-wood and Lima-wood (a sort of Brazil-wood).

Chinese  
gall-nuts.

**Chinese Gall-nuts.**—L. F. Bley(1) has made an analysis of the Chinese gall-nuts with reference to their commercial value. Of 100 parts of the substance, ether extracted 76 parts; amongst these were 3 parts of fat and resin capable of being separated by water, then an amount of gallic acid which Bley calculates at 4 per cent (in these 4 per cent those substances are included which water afterwards extracts from the residue; according to a former part of the paper these substances were not included). The residue, exhausted with ether, was now treated with water, and thus small quantities of soluble salts, of gallic acid, extractive matter, albuminous substances and traces of starch were obtained. A special experiment gave the amount of moisture at 8 per cent.—In the meantime, warned by W. Stein's analysis (Annual Report for 1849, III, 501) Bley rectified his analysis (towards the end of the treatise) by making a determination of the amylon with the substance exhausted by ether and alcohol, according to the method of Krockner. This yielded, instead of traces of amylon, 7.35 per cent of it.—Bley found the ash of the Chinese gall-nuts alkaline, nearly free from lime, but rich in potassa and phosphoric acid.

(1) Arch. Pharm. [2] LXI, 297.

# MINERALOGY.

General  
matters.

**General Matters.**—For all that relates to Isomorphism, Dimorphism, Polymerism, and Heteromorphism, see p. 17, *et seq.*

**Conductivity of Minerals for the Galvanic Current as a Mineralogical Character.**—Kobell(1) has proposed to employ the relative conductivity of minerals for the galvanic current as a mineralogical character. A strip of sheet-zinc, about 6 inches long and  $\frac{1}{4}$  of an inch broad, is to be bent into a pair of tongs, with which a very small fragment of the mineral under examination is to be taken up and plunged for about a minute in a solution of blue vitriol. Good conductors become entirely covered with copper; bad conductors exhibit this deportment only at the points of contact with the zinc; and non-conductors, not at all. The good conductors comprise: the native metals (tellurium excepted), fahl-ore, mispickel, galena, chalcosine, cobaltine, smaltine, pyrrhotine, pyrites, "wasserkies," copper pyrites, linnæite, magnetite, graphite, and many others. The bad conductors include bourhonite, bismuthine, argyrose, molybdenite, argyrythrose, proustite, zinc-blende, and titanite iron from Egersund. On the other hand, red antimony, stibine, alabandine, argentiferous fahl-ore, chromic iron, franklinite, specular iron from the Fichtelgebirge and from Elba, pyrolusite, braunite, hausmanite, manganite, psilomelane, rutile, cassiterite, and ruberite, belong to the non-conductors.

Many minerals which otherwise resemble one another, may be readily distinguished by the above method. Magnetite from chromic iron, for example, galena from stibine, and fahl-ore from bournonite.—Only a few varieties of anthracite are conductors; the greater number are not so. All varieties, however, of coal and lignite become conductors after ignition before the blow-pipe: a fact which proves that the naturally-conducting specimens of anthracite must have been exposed to a high temperature. Kobell thus points out that his method may become of great importance in its applications to Geology.

**Hardness. (Its Determination and Laws.)**—R. Franz(2) has described a new apparatus for the determination of the degree of hardness in minerals. This instrument, similar in its general con-

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(1) From the Anzeigen der Münchener Academie in J. Pr. Chem. L, 76.

(2) Pogg. Ann. LXXX, 37; Sill. Am. J. [2] XI, 225 (in abstr.)

struction to that of Seebeck, contains a steel or diamond point set at right angles to the surface of the mineral to be examined, and is so contrived that the harder the mineral, the more must this point be loaded in order to scratch the substance when drawn forwards; but, the softer the mineral, the greater the weight necessary to draw the point sideways while it effects a scratch.—By means of an apparatus constructed after this principle, Franz has submitted the members of Mohs's scale, and a few other minerals, to an examination, the result of which, as already detected in part by Frankenheim and Seebeck, is, that the same plane scratched in different directions, exhibits in many instances very unequal degrees of hardness. In gypsum, for example, the greatest hardness on the cleavage-planes is found in a direction about  $20^{\circ}$  right or left from the shorter diagonal of the cleavage-rhomboid; whilst the lowest degree of hardness lies in a direction at right angles to the former. Calcareous spar exhibits a two-fold hardness, according as it is scratched backwards or forwards on the cleavage-planes in the direction of the shorter diagonal of the rhomb. In the direction of the longer diagonal no such difference occurs.—Franz considers the cleavage-lines in minerals to be the cause of these phenomena, and deduces from his experiments the following laws: On planes cut by the cleavage-line, the softest direction lies at right angles to the direction of the cleavage. The hardest direction in a given crystal is that which is parallel to the cleavage-planes; and of different faces belonging to the same crystal, that one is the hardest which is cut by the planes of the most perfect cleavage.

Hardness.  
(Its deter-  
mination  
and laws.)

**Metalloids. The Diamond.**—G. Wilson(1) has suggested that the diamond may very possibly originate from anthracite without the solid condition of the latter being changed. As hydrogen, oxygen, nitrogen and sulphur, together with part of the carbon, may be gradually eliminated from anthracite in the form of volatile compounds, the residue of the carbon might assume the crystalline state by a change in the allotropic condition of its atoms. A low temperature, combined with the slow development of the process, might produce the diamond, whilst a high temperature and rapid development would give rise to graphite. In announcing this view, however, Wilson does not wish it to be inferred that the diamond may not also have been formed under other circumstances.

C. Zerenner(2), formerly director of the Adolphsk diamond mine, near Krestowosdwichensk, on the European slope of the Urals, has communicated a description of this mine, together with a catalogue of all the diamonds found in it, or its vicinity, from the year 1830

(1) Proceed. of the Roy. Soc. of Edinb. 1850, 301; Edinb. New Phil. Journ. Jan. to April, 1850; Instit. 1850, 285 (in abstr.); Arch. Ph. Nat. XV, 144; Forriep's Tagesberichte üb. d. Fortschritte d. Natur- u. Heilkunde, 1850, No. 174.

(2) Zeitschrift der Deutschen Geologischen Gesellsch. I, 482; Jahrb. Miner. 1850, 237 (in abstr.); Arch. Ph. Nat. XV, 327.



Metal-  
loids.  
The  
diamond.

up to the end of 1847. The catalogue also enumerates the respective weights of these diamonds, and the days on which they were found. They amount to 64 specimens, chiefly icositessrahedrons, of an average weight of  $\frac{5}{8}$  of a carat. The largest amongst them weighed 1 carat and  $\frac{3}{4}$ .—At the present time, diamonds are only obtained in this locality at the gold-washings, as it does not pay to search for them expressly.

Kessel has made an exceedingly interesting verbal communication to C. Zerrenner(1) on the occurrence, &c., of diamonds in Borneo. These are found more particularly in the districts of Lándak, Sekajam and Tajan in the north-west of the island, and in the Banjarmassing country in the south-east. They occur in a talcose rock of from 2 to 4 yards in thickness, consisting of a blueish-grey basis, with white pebbles. The latter are probably quartz.

According to a Report, addressed to the Secretary of State at Washington, by R. M. Patterson(2), director of the Mint in Philadelphia, the occurrence of diamonds in the gold-washings of the United States is proved beyond doubt. Nine specimens are cited from the gold-washings of the southern Alleghanies, a locality in which the occurrence of diamonds had been long predicted by Humboldt. Patterson is also acquainted with 3 specimens from the gold-regions of North Carolina(3). Lyman(4) has seen a diamond from California. It possessed curved faces, was of a straw-yellow colour, and as large as a pea.

**Metals. Platinum.**—According to R. M. Patterson(5), the gold-sand of California contains also platinum and osmium-iridium. The former may be seen in the gold-dust with the naked eye; and J. E. Teschemacher(6) has picked out about 50 granules from an ounce of this dust. According to his opinion, the Californian gold-dust contains as much platinum as that from South America.—From the statement of W. Mallet(7), platinum occurs likewise in the gold-sands of County Wicklow in Ireland.

**Gold.**—A sample of native gold from the river-sand of this latter locality has been analyzed by W. Mallet(8). Its spec. grav. was equal to 16.34, and it contained in 100 parts: gold 92.32, silver 6.17, iron 0.78.

R. M. Patterson(9), has reported the occurrence of several large

(1) Zeitschrift d. Deutschen Geolog. Gesellsch. II, 404.

(2) Ibid. 61; Jahrb. Miner. 1851, 351 (in abstr.).

(3) Annual Report for 1847 and 1848, II, 383.

(4) Sill. Am. J. [2] VIII, 294.

(5) Zeitschr. d. Deutschen Geolog. Gesellsch. II, 61; Jahrb. Miner. 1851, 351 (in abstr.).

(6) Sill. Am. J. [2] X, 121 and Dana's Syst. of Min. 3rd edit. 691.

(7) Phil. Mag. [3] XXXVI, 393; Sill. Am. J. [3] XI, 232 (in abstr.).

(8) Phil. Mag. [3] XXXVII, 393.

(9) Zeitschrift der Deutschen Geolog. Gesellsch. II, 60.

specimens of gold in the United States of North America. According to his announcement, the quantity of Californian gold supplied to the Mint in Philadelphia, up to the 4th of October, 1849, amounted in value to  $3\frac{1}{2}$  millions of dollars. M. von Gerolt(1) the Prussian ambassador at Washington, states, in a letter to Humboldt, that the amount had reached 8 millions at the date of his communication, February 15th, 1850. This quantity, however, falls far short of the gold produce of Russia, which at present amounts to 2000 puds, or, in value, to 26,980,800 thalers (£3,844,764).—F. Alger(2) has described an octahedron of Californian gold  $\frac{1}{16}$  of an inch in height.

According to Emmons(3), a new and very productive gold locality has been discovered on Samuel Elliot's farm, in Montgomery County, in Maryland. The gold lies in quartz-veins in a decomposed talc-slate.

**Alloy of Copper and Silver.**—F. Field(4) has found a whitish alloy of copper and silver in a mine 20 miles east of Coquimbo. One specimen contained 1.09 per cent of silver; and a second specimen, 7.60 per cent of the same.

**Copper.**—According to Oszwaldt(5), a lump of native copper, 30 lbs. in weight, has been found lying exposed on the surface of the ground, in the vicinity of a vein of copper-ore near Reesk, in Hungary.

**Tellurides. Tetradymite.**—C. J. Jackson(6) has now examined the tetradymite of Whitehall in Virginia, which was made known by him some time ago(7), and first analyzed by C. Fisher(8). Jackson, however, finds in it only traces of selenium.—His analysis gave :

| Bi.   | Te.   | S.   | Gold, sesquiox. of iron and matrix. | Total. |
|-------|-------|------|-------------------------------------|--------|
| 58.80 | 35.05 | 3.65 | 2.70                                | 100.20 |

He states that the ore occurs in quartz-veins and in mica-slate in the form of nodules coated with yellow oxide of bismuth, and in foliated masses. Gold occurs between the foliæ. As tetradymite, according to Haidinger, possesses nearly the same angles and cleavage as antimony, and crystallizes in the same compound forms, G. Rose(9) considers it to be isomorphous with the rhombohedral metals(10). He thinks that the difference between the angles of these latter and those of the tetradymite, may very possibly

(1) Zeitschrift der Deutschen Geologisch. Gesellsch. II, 64.

(2) Dana's Syst. of Min. 3rd edit. 685; Sill. Am. J. [2] X, 101.

(3) Proceed. of the Am. Phil. Soc. 1849, 85; Sill. Am. J. [2] IX, 126 (in abstr.); Instit. 1850, 223.

(4) Chem. Soc. Qu. J. III, 29; Sill. Am. J. [2] X, 225 (in abstr.)

(5) Haidinger's Berichte üb. d. Mittheil. von Freunden d. Naturwissenschaften, VI, 149.

(6) Sill. Am. J. [2] X, 78; Dana's System of Min. 3rd edit. 695, 712.

(7) Annual Report for 1847 and 1848, II, 385.

(8) Annual Report for 1849, III, 504.

(9) Berl. Acad. Ber. 1850, 260.

(10) See p. 17.

Arsenides.  
Glauco-  
dote.

be owing to the assumption of the form of tellurium by the small and immaterial portion of sulphur present in the mineral.

**Arsenides. Glaucodote.**—A. Breithaupt(1) has received from Dr. Bondi, under the appellation of radiated cobalt-glance from Oravicza in the Bannat, a specimen of finely prismatic glaucodote, possessing the perfect  $\infty P$  cleavage as well as the other characteristic properties of the mineral from Chili(2). Its composition, according to an analysis by A. Paterson, is as follows: . . .

|   | S.    | As.   | Co.   | Fe.  | Total. |
|---|-------|-------|-------|------|--------|
| " | 19.78 | 43.63 | 32.02 | 4.56 | 99.99  |

**Cobaltine.**—Schnabel(3) has examined a mineral allied to cobaltine from the mine Grüner Löwe(I) and Hamberg(II) near Gosenbach in the Siegen district, where it was known by the name of Stahlkobalt, or fibrous Speiskobalt. It occurs in fibrous, prismatic, or foliated crystalline masses, possessing an apparently hexahedral cleavage, a metallic lustre and a steel-grey colour with a reddish-violet iridescence. Hardness=5.5; spec. grav., in the purer varieties (II), =5.33.—On charcoal, before the blow-pipe, it emits sulphurous and arsenical odours, and fuses with difficulty to an iron-black magnetic globule, which presents on the fracture a bronze-yellow colour:

|     | S.    | Fe.   | Co.  | Sb.  | As.   | Total.  |
|-----|-------|-------|------|------|-------|---------|
| I.  | 19.98 | 25.98 | 8.67 | 2.84 | 42.53 | 100.00* |
| II. | 20.86 | 28.03 | 8.92 | —    | 42.94 | 100.75  |

\* Calculated to 100 parts, after deduction of 3.69 per cent of silicious residue.

**Enargite.**—A. Breithaupt(4) has announced as a new species, under the name of enargite (*εναργής*) from its very facile cleavage, a mineral belonging to the Glance family, from the mine of San Francisco near Morochocha, on the Cordilleras of Peru, where it is largely smelted as a copper-ore. The crystals are combinations of a rhombic prism  $\infty P$  with an, as yet, undefined pyramid  $n\check{P}m$ , besides  $\infty\check{P}$ ,  $\infty$ ,  $\infty\check{P}\infty$ ,  $0P$ , and traces of a second prism, which is probably  $\infty\check{P}2$ . They are perfectly cleavable in the direction of  $\infty P$ ; tolerably so in that of  $\infty\check{P}\infty$  and  $\infty\check{P}$ ; indistinctly, parallel to  $0P$ ; and in traces parallel to  $n\check{P}m$ . Breithaupt found the angles of the cleavage planes parallel to  $\infty P=98^{\circ}10'45''$  in the brachydiagonal principal section. Massive specimens have a coarsely granular structure inclining to prismatic. Colour and streak, iron-black; hardness (by Mohs's scale)=3; spec. grav.=4.430 to 4.445.—According to

(1) Pogg. Ann. LXXXI, 478.

(2) Annual Report for 1849, III, 505.

(3) Verhandl. d. Nat. Vereins d. preuss. Rheinl. 7 Jahrg. 1850, 158.

(4) Pogg. Ann. LXXX, 383; Arch. Ph. Nat. XV, 245 (in abstr.); Phil. Mag. [4] I, 411.

Plattner's examination, the mineral decrepitates strongly when heated in the bulb-tube, producing a sublimate of sulphur and sulphide of arsenic, and ultimately fusing if the heat be continued. In the open tube it gives off sulphurous and antimonious acid; and, on charcoal, it melts to a globule, with evolution of sulphide of arsenic, and deposition of arsenious acid, teroxide of antimony, and oxide of zinc. The residue obtained by heating the mineral upon charcoal, when tested with borax or phosphorus-salt, exhibits the reaction of copper and iron. Sulphide of arsenic and sulphide of antimony are dissolved out by caustic alkalies.

Enargite

A quantitative analysis gave the following results:

| S.     | As.    | Sb.   | Cu.    | Fe.   | Zn.   | Ag    | Total. |
|--------|--------|-------|--------|-------|-------|-------|--------|
| 32.222 | 17.599 | 1.613 | 47.205 | 0.565 | 0.228 | 0.017 | 99.449 |

Plattner deduces from the above the accompanying proportions for the equivalents of S : (As, Sb) : (Cu, Fe, Zn) = 16.05 : 1.97 : 12.14 = 8 : 1 : 6; from which he constructs the formula  $8 \text{CuS}, \text{AsS}_3 + 2 \text{Cu}_2\text{S}, \text{AsS}_3$ ; or,  $3 (\text{Cu}_2\text{S}, \text{FeS}, \text{ZnS}) + (\text{AsS}_5, \text{SbS}_5)$  analogous to that of the sulpharsenite  $3\text{AgS}, \text{AsS}_5$  present in Xanthokon(1).

**Sulphides, Kupferindig.**—Ch. Grimm(2) has found that the compact Kupferindig from the Stangenwage mine, near Dillenburg, exhibits a mixture of 66.82 of sulphide of copper (CuS, covelline), with 3.96 of pyrites, 18.63 of quartz, and 10.57 of sesquioxide of iron, sesquioxide of manganese and water.

**Zinc-Blende.**—Jackson(3) has analyzed three specimens of zinc-blende, remarkable for their richness in cadmium: (I) from Eaton, (II) from Shelburne, and (III) from Lyman, in New Hampshire.

|      | Zn.   | Fe.   | Cd.  | S.    | Total. |
|------|-------|-------|------|-------|--------|
| I.   | 63.62 | 3.10  | 0.60 | 33.22 | 100.54 |
| II.  | 52.00 | 10.00 | 3.20 | 32.60 | 97.80  |
| III. | 55.60 | 8.40  | 2.30 | 33.40 | 99.70  |

**Copper Pyrites.**—Three specimens of copper pyrites, (I) from Kaaford, (II) from Areskuttan, and (III) from Tunaberg, have been analyzed by Malaguti and Durocher(4).

|      | Cu.   | Fe.   | S.    | Gangue. | Total. |
|------|-------|-------|-------|---------|--------|
| I.   | 32.73 | 28.51 | 38.76 | —       | 100.00 |
| II.  | 41.00 | 18.92 | 30.17 | 9.91    | 100.00 |
| III. | 49.49 | 11.08 | 34.71 | 4.72    | 100.00 |

**Anhydrous Oxides. Spartalite or Red Zinc-ore.**—According to A. A. Hayes(5), the red colour of the spartalite from Franklin, arises

(1) Pogg. Ann. LXIV, 272.

(2) Jahrbuch d. Ver. f. Naturk. im Herzogth. Nassau, 4 Heft, 141.

(3) In abstr. from the Geological Report of New Hampshire, by C. T. Jackson, 208, in Dana's Syst. of Mineral. 3rd edit. 479.

(4) Ann. Min. [4] XVII, 299.

(5) Sill. Am. J. [2] IX, 424; Dana's Syst. of Mineral. 3rd edit. 481 (in abstr.)

Black  
copper.

from an admixture of transparent scales of specular iron; and the manganese is present in the state of protoxide.

**Black Copper.**—The black copper from Copper Harbor, mentioned in the Report for 1849, III, p. 512, possesses, according to Rammelsberg(1), a spec. grav. of 5.952. Teschemacher and Hayes(2) make this in the crystalline specimens = 5.141, and in the compact masses = 5.386. Joy has examined it chemically, under Rammelsberg's direction, and found it to contain 99.45 per cent of oxide of copper. In another specimen, 1.19 of oxide of iron, 0.23 of lime, and 3.38 of silica, were present.

**Rutile.**—F. A. Alger(3) and O. P. Hubbard(4) have described rutiferous quartz from North America.

**Brookite (Arcansite).**—The brookite described by Romanowsky in the gold-washings of the Atliansky mine, not far from Miask, and already described by Hermann(5), has also been subjected by Kokscharow(6) to a crystallographic investigation. In the small crystals with numerous facettes, which, in colour and prismatic configuration, resemble those of St. Gotthard, he has defined, besides the already known forms,  $\frac{1}{2}P$  (=  $b \frac{1}{2}$  of Levy),  $\bar{P}2$  ( $c^3$ ),  $0P$ ,  $\infty\bar{P}\infty$ ,  $\infty\bar{P}\infty$ ,  $\frac{2}{3}\bar{P}\infty$  ( $c^3$ ),  $\frac{1}{4}\bar{P}\infty$  ( $a^2$ ),  $\frac{1}{2}\bar{P}\infty$  ( $e^4$ ?), and  $\infty P$  ( $m$ ), the following new forms, namely:  $\bar{P}$ ,  $2P$ ,  $2\bar{P}\frac{7}{8}$ ,  $2\bar{P}2$ ,  $5\bar{P}\frac{10}{3}$ ,  $\frac{2}{3}\bar{P}\frac{2}{3}$ ,  $2\bar{P}\infty$ ,  $\infty\bar{P}2$  (=  $\infty\bar{P}n$ , Hermann?)  $\infty\bar{P}\frac{2}{3}$  and  $\infty\bar{P}\frac{1}{4}$ . In this view, Levy's prism  $m$  (=  $\infty\bar{P}2$ , according to the position assumed by Naumann) becomes the chief prism; and the pyramid, set upon the basal edges of this, constitutes the normal octahedron  $P$ , the angles of which, as calculated by Kokscharow, equal in the macrodiagonal principal section,  $101^\circ 34' 54''$ ; in the brachydiagonal principal section,  $115^\circ 43' 2''$ ; and in the basal section,  $111^\circ 25' 34''$ .—He likewise gives the following angles as the result of repeated measurements:  $\infty P = 99^\circ 50' 2''$  and  $80^\circ 10' 3''$ ;  $P2$  (=  $\bar{P}$ , after Naumann's position) in the brachydiagonal principal section =  $135^\circ 37' 5''$ ;  $\bar{P}2 : \infty\bar{P}\infty = 112^\circ 11' 11''$ , and  $\bar{P}2 : \infty P = 134^\circ 18' 28''$ . All the 25 specimens examined by Kokscharow consisted of twin crystals, with the planes of junction parallel to  $\infty\bar{P}\infty$ , and having slightly-marked vertical striæ on the planes  $\infty\bar{P}\frac{2}{3}$ .—G. Rose(7) defines the latter form more simply as  $\infty\bar{P}8$ , after its inclination on  $\infty P$ , which he

(1) Pogg. Ann. LXXX, 286.

(2) Dana's Syst. of Mineral. 3rd edit. 518.

(3) Sill. Am. J. [2] X, 77.

(4) From the Proceedings of the American Association for the Advancement of Science, Newhaven, 1850, in Sill. Am. J. [2] X, 350.

(5) See Annual Report for 1849, III, 512.

(6) Pogg. Ann. LXXIX, 454; Sill. Am. J. [2] XI, 228 (in abstr.)

(7) Pogg. Ann. LXXIX, 464.

found, in a crystal received from Kokscharow, to equal  $148^{\circ} 15'$  —  $148^{\circ} 20'$ ; he considers it, moreover, probable that Kokscharow's  $\infty P \frac{1}{2}$  may be also  $\infty P 8$ .—Frödmann found the spec. grav. of the ural brookite = 4.22; Beck found the same = 4.20; and Romanowsky = 4.216.

Brookite  
(Arcan-  
site).

The identity of arcansite and brookite has been proved also by Hermann(1). Admitting the normal position assumed by Breithaupt(2), he found for P the angles  $135^{\circ} 30'$ ,  $94^{\circ}$ , and  $101^{\circ}$ ; whilst an analysis gave the following results: . . .

| $TiO_2$ | $Fe_2O_3$ | UO.   | $SiO_2$ and gangue. | Total. |
|---------|-----------|-------|---------------------|--------|
| 96.50   | 1.00      | trace | 2.50                | 100.00 |

**Cassiterite (Tinstone).**—According to W. Mallet(3), the gold sand of County Wicklow in Ireland, contains tinstone in the form of wood-tin, and in rolled crystals. One of the latter, possessing a spec. grav. of 6.753, exhibited the following composition: .

| $SnO_2$ | $Fe_2O_3$ | $SiO_2$ | Total. |
|---------|-----------|---------|--------|
| 95.26   | 2.41      | 0.84    | 98.51  |

**Corundum and Emery.**—L. Smith(4) has given a detailed account of the emery discovered by him(5) in Asia Minor. Its principal localities, from whence it is already exported in considerable quantities as an article of commerce, are the Gummuchdagh mountain, the environs of Kulah, and the Island of Nicaria. Emery occurs besides near Adula and Manser, and in Samos. It is found at all these localities either quite exposed, or in a reddish clay, and principally in the form of angular fragments about as large as a pea; very frequently, however, masses occur several thousand kilgrms. in weight. Its parent site, as at Naxos, is a white or bluish granular limestone, overlying the older stratified or azoic rocks. In the immediate vicinity of the emery, the limestone is stained dark-yellow by sesquioxide of iron.—According to Smith, this emery is an intimate mixture of corundum, magnetic and specular iron; the three minerals being sometimes perfectly distinguishable by the microscope. In the specimens from Gummuchdagh, for example, the corundum is often found in large pieces, quite distinct, or mixed with diaspore or emeryllite. It is also met with crystallized in hexagonal prisms, and these frequently possess pyramidal terminations. The corundum of Kulah and Adula is dark grey, but all the other specimens from Asia Minor are blue.

(1) J. Pr. Chem. L, 200; Sill. Am. J. [2] XI, 229 (in abstr.)

(2) See Annual Report for 1849, III, 512.

(3) Phil. Mag. [3] XXXVII, 394.

(4) Sill. Am. J. [2] X, 354; Ann. Min. [4] XVIII, 259; Compt. Rend. 1850, XXI, 193, 611 (in abstr.); Instit. 1850, 225; Phil. Mag. [3] XXXVII, 396.

(5) See Annual Report for 1847 and 1848, II, 391; Annual Report for 1849 III, 515.

Corundum  
and  
emery.

Smith has also performed a series of analyses on sapphire, corundum(1), and emery(2), in which decomposition was effected by fusion with bisulphate of soda. As a means, furthermore, of valuing these minerals in a technical point of view, he has defined their relative degrees of hardness by rubbing equal quantities, in a correspondingly fine state of division, on a weighed glass plate, until the weight of this latter appeared to remain constant. In the following table, the column headed "hardness" contains, according to this original method, the relative values of the specimens submitted to analysis. The loss in weight exhibited by the glass plate when rubbed with blue sapphire from Ceylon, is made=100.

| Localities.            | Hardness. | Sp. gr. | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO. | SiO <sub>2</sub> . | H <sub>2</sub> O. | Total. |
|------------------------|-----------|---------|----------------------------------|----------------------------------|------|--------------------|-------------------|--------|
| CRYSTALLIZED CORUNDUM. |           |         |                                  |                                  |      |                    |                   |        |
| a. Sapphire.           |           |         |                                  |                                  |      |                    |                   |        |
| India (sapphire)       | 100       | 4.06    | 97.51                            | 1.89                             | —    | 0.80               | —                 | 100.20 |
| " (ruby)               | 90        | 4.08    | 97.32                            | 1.09                             | —    | 1.21               | —                 | 99.62  |
| b. Corundum.           |           |         |                                  |                                  |      |                    |                   |        |
| Asia Minor             | 77        | 3.88    | 92.39                            | 1.67                             | 1.12 | 2.05               | 1.60              | 98.83  |
| Nicaria                | 65        | 3.92    | 87.52                            | 7.50                             | 0.82 | 2.01               | 0.68              | 98.53  |
| Asia Minor             | 60        | 3.60    | 86.62                            | 8.21                             | 0.70 | 3.85               | 1.66              | 101.04 |
| India                  | 58        | 3.89    | 93.12                            | 0.91                             | 1.02 | 0.96               | 2.86              | 98.87  |
| Asia Minor             | 57        | 3.80    | 87.32                            | 3.12                             | 1.00 | 2.61               | 3.74              | 97.79  |
| India                  | 55        | 3.91    | 84.56                            | 7.06                             | 1.20 | 4.00               | 3.10              | 99.92  |
| EMERY.                 |           |         |                                  |                                  |      |                    |                   |        |
| Kulah                  | 57        | 4.28    | 63.50                            | 33.25                            | 0.92 | 1.61               | 1.90              | 101.18 |
| Samos                  | 56        | 3.98    | 70.10                            | 22.21                            | 0.62 | 4.00               | 2.10              | 99.03  |
| Nicaria                | 56        | 3.75    | 71.06                            | 20.32                            | 1.40 | 4.12               | 2.53              | 99.43  |
| Kulah                  | 53        | 4.02    | 63.00                            | 30.12                            | 0.50 | 2.36               | 2.36              | 98.34  |
| Gummuch                | 47        | 3.82    | 77.82                            | 8.62                             | 1.80 | 8.13               | 3.11              | 99.48  |
| Nicaria                | 46        | 3.74    | 75.12                            | 13.06                            | 0.72 | 6.88               | 3.10              | 98.88  |
| Naxos                  | 46        | 3.75    | 68.53                            | 24.10                            | 0.86 | 3.10               | 4.72              | 101.31 |
| Naxos                  | 44        | 3.87    | 59.46                            | 19.08                            | 2.81 | 2.41               | 5.47              | 99.23  |
| Gummuch                | 42        | 4.31    | 60.10                            | 33.20                            | 0.48 | 1.80               | 5.62              | 101.20 |
| Kulah                  | 40        | 3.89    | 61.05                            | 27.15                            | 1.30 | 9.63               | 2.00              | 101.1  |

As all the specimens of corundum analyzed by Smith contained water, whilst the sapphires were anhydrous, he considers it not improbable, that the former substance may be produced by aqueous, and the latter by igneous agencies; in support of which, he calls attention, first to their structural dissimilarity—corundum possessing a rhombohedral cleavage, and sapphire an imperfect cleavage parallel to  $\infty P(3)$ ; secondly, to the fact of the rhombohedral form (R. O R) of sapphire produced artificially by Ebelmen(4), ut never

(1) Ann. Min. [4] XVIII, 287 (for corundum and emery).

(2) Sil. Am. J. [2] X, 354 (for emery only).

(3) See Dufrénoy's *Traité de Minéralogie*, II, 235, 340.

(4) See Annual Report for 1847 and 1848, I, 17.

found by him in the corundum crystals of Asia Minor; and finally, to the association of this latter with diaspore.

Landerer(1) has found the following composition for an emery from the vicinity of the village of Mastiches in Naxos:

Corundum  
and  
emery.

| $\text{Al}_2\text{O}_3$ . | $\text{Fe}_2\text{O}_3$ . | $\text{SiO}_2$ . | HO and loss. | Total. |
|---------------------------|---------------------------|------------------|--------------|--------|
| 65                        | 16                        | 9                | 10           | 100    |

**Hydrated Oxides. Fire-opal.**—According to G. J. Brush(2), the fire-opal of Washington County in Georgia, is composed as follows:

| $\text{SiO}_2$ . | $\text{Al}_2\text{O}_3$ . | $\text{MgO}$ . | HO.  | Total. |
|------------------|---------------------------|----------------|------|--------|
| 91.89            | 1.40                      | 0.02           | 5.84 | 99.15  |

**Nemalite (Brucite).**—Rammelsberg(3) has examined a light-green mineral of a satiny lustre and parallel fibrous structure, which he received, under the denomination of nemalite from Hoboken. He found it, as had been shown by Whitney(4), to be merely a fibrous variety of brucite. Its analysis gave the following results:

| $\text{MgO}$ . | $\text{FeO}$ . | HO.   | $\text{SiO}_2$ . | Total. |
|----------------|----------------|-------|------------------|--------|
| 64.86          | 4.05           | 29.48 | 0.27             | 98.66  |

**Hydrargillite.**—Kobell(5) has found in a Brazilian hydrargillite, received from Lomel of Heidelberg, 67.26 per cent of alumina, with a trace of silica, and 32.39 per cent of water. He did not meet with any phosphoric acid. The mineral formed an incrustation of a radiating-foliated structure on disintegrated mica-slate; and was transparent, greyish-white, and vitreous—except upon the cleavage-planes, which were pearly. Hardness, according to Kobell's determination = 3.5. By means of a lens, Kobell fancied that he discovered here and there, rectangular prisms.

**Diaspore.**—L. Smith(6) has found diaspore in almost every specimen of emery from Asia Minor; and in unison with the opinion advanced by him, that this mineral will be always met with accompanying corundum, Descloizeaux has also discovered it in the emery from Naxos. It occurs in the emery in the form of yellowish, or sometimes brilliantly white, foliated masses possessing a strong lustre; or as delicate needles, which are dispersed through the substance of the emery in all directions, and often without any visible limitation. Perfect crystals are only met with in isolated individuals, imbedded in brown iron-ore at the Gummuchdag. A. Dufrénoy(7)

(1) Jahrb. Miner. 1850, 681.

(2) Dana's Syst. of Mineral. 3rd edit. 691.

(3) Pogg. Ann. LXXX, 284; Sill. Am. J. [2] XI, 225.

(4) See Annual Report for 1849, III, 516.

(5) J. Pr. Chem. L, 493.

(6) Ann. Min. [4] XVIII, 290.

(7) Compt. Rend. XXXI, 185; Ann. Min. [4] XVIII, 35; Instit. 1850, 257 (in abstr.)



**Diaspore** has found that the measured angles of these agree exactly with Marignac's measurements(1) of the diaspore from St. Gotthard. Thus,  $\infty P = 130^\circ 2'$ , and  $P = 151^\circ 35'$ , both in the brachydiagonal principal section. Dufrenoy has also convinced himself that the angle of  $P \infty P = 125^\circ 17'$  both at the back and front of the crystal; and that diaspore, consequently, as first shown by Haidinger, belongs to the orthometric (trimetric) system. The crystals possess the same general form as those from St. Gotthard, and exhibit most distinctly the pleochroism which Haidinger first pointed out as a character of certain diaspores. Smith found their spec. grav.  $\approx 3.45$ .—The specimens made use of by the latter chemist in the following analyses consisted of (I) crystals from the Gummuchdagh; these were stained somewhat yellow by sesquioxide of iron, contained between the lamellæ, (II) foliated diaspore from the same locality, and (III) foliated diaspore from Naxos.

|     | $Al_2O_3$ | $Fe_2O_3$ | CaO   | $MgO$ | $SiO_2$ | HO.   | Total |
|-----|-----------|-----------|-------|-------|---------|-------|-------|
| I   | 82 20     | 1 20      | 0 41  | trace | 0 67    | 14 52 | 99 00 |
| II  | 83 12     | 0 66      | trace | trace | 0 82    | 14 28 | 98 88 |
| III | 82 94     | 1 06      | 0 35  | trace | 0 26    | 14 21 | 98 82 |

**Oxides (RO) with Sesquioxides ( $R_2O_3$ ).** **Iserine.**—T. S. Hunt(2) has analyzed the titanio-iron (iserine or ilmenite?) which occurs in very large amorphous, and occasionally granular, masses in syenite at St. Paul's Bay, Canada (I). Colour and streak, black; hardness = 6; spec. grav. 4.56 to 4.66, very feebly magnetic.—L. Smith(3) has found titanio-iron constantly accompanying the emery of Asia Minor, and he has analyzed a specimen of the same from Nicaria (II). Ignited in oxygen-gas, it increased 0.019 in weight, whilst, by ignition in hydrogen, it suffered a loss of 0.222.

|    | $Fe_2O_3$ | $Ti_2O_3$ | $TiO_2$ | FeO * | $Al_2O_3$ | CaO  | MgO  | Total. |
|----|-----------|-----------|---------|-------|-----------|------|------|--------|
| I  | —         | 48 60     | —       | 46 44 | —         | —    | 3 60 | 98 64  |
| II | 55 00     | —         | 23 01   | 17 10 | traces    | 1 00 | —    | 96.11  |

\* Part of the iron is present in this ilmenite in the state of sesquioxide.

**Chromolite (Chromic Iron).**—L. E. Rivot(4) has applied his newly-invented process for the determination of the amount of oxide of iron in minerals by reduction in hydrogen(5), to the analysis of chromic iron from Baltimore (I). Landerner(6) has analyzed chromic iron from Iham, and from the Isle of Seiro.

(1) See the Report for 1847 and 1848, II, 393. A misprint, however, occurs there; in lines 21 and 22; for  $2P$  read  $\infty P$ , and for  $\infty P$  read  $2P$ .

(2) Sil. Am. J. [2] XI, 231, in Logan's Geolog. Rep. of Canada, 1850.

(3) Ann. Min. XVIII, 30.

(4) Ann. Ch. Phys. [3] XXX, 202.

(5) See p. 407.

(6) Jahrb. Miner. 1850, 682.

|      | Cr <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO.  | CaO. | MgO. | SiO <sub>3</sub> or TiO <sub>2</sub> . | Total. | Chromo-<br>lite<br>(Chromic<br>iron). |
|------|----------------------------------|----------------------------------|----------------------------------|-------|------|------|----------------------------------------|--------|---------------------------------------|
| I.   | 63·37                            | 30 04                            | 1·96                             | —     | 2 02 | —    | 2·21                                   | 99 60  |                                       |
| II.  | 42·00                            | —                                | 16·00                            | 34·00 | —    | 5·00 | —                                      | 97·00  |                                       |
| III. | 54·00                            | —                                | 18·00                            | 20·00 | —    | 8·00 | —                                      | 100·00 |                                       |

It will be seen by the above, that Rivot's analysis presents a very striking result, inasmuch as the chromolite contains all its iron in the condition of sesquioxide, and does not, consequently, belong to the spinel group!

T. H. Garret(1) has analyzed the chromic iron of Texas in Lancaster County, Pennsylvania—the same variety in which the emerald nickel occurs. (See the Report for 1817 and 1818, *Id.*, p. 448). The analysis yielded 93·16 per cent of chromic iron, 5·29 of magnetic iron, and 2·28 of oxide of nickel.

**Artificial Silicates (Slags).** **Chytrophyllite.**—J. F. L. Hausmann(2) has described in detail, amongst other kindred products, a somewhat rare slag from a blast-furnace, to which, on account of its origin and remarkable coarsely-foliated structure, he has given the name of chytrophyllite (fused-foliated). He obtained it from the iron furnaces of Neuwerk and Altenau, and, in specimens of especial beauty, from the blast-furnaces (now closed) at Elend in the Hartz. Lustre, vitreo-pearly; transparent in thin pieces; colour, dark pearl-grey to lavender-blue, with here and there a silvery appearance and variegated tarnish; streak-powder, light steel-grey; hardness=5·5; spec. grav.=2·910. Before the blow-pipe it fuses easily, and with bubbling, to a greenish-black, non-magnetic pearl. An analysis made by A. Knop gave the following results:

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO.   | CaO.   | Total.  |
|--------------------|----------------------------------|--------|--------|---------|
| 54·897             | 5·078                            | 20·794 | 20·346 | 101·115 |

Hausmann deduces from the above, by uniting the silica and alumina, the formula RO, R<sub>2</sub>O<sub>3</sub>.

**Anhydrous Silicates of RO.** **Steatite.**—Th. Bromeis(3) has analyzed steatite from Stecklenberg in the Hartz, where it occurs in soft, saponaceous lumps, imbedded in gypsum:

| SiO <sub>3</sub> . | MgO.   | FeO.  | Coal and bitumen. | Total. |
|--------------------|--------|-------|-------------------|--------|
| 62·964             | 30·976 | 0·639 | 4·083             | 98·662 |

**Wollastonite.**—J. B. Bunce(4) has found wollastonite from Grenville in Canada, to be composed as follows:

| SiO <sub>3</sub> . | CaO.  | FeO. | Total. |
|--------------------|-------|------|--------|
| 53·05              | 45·71 | 1·20 | 99·99  |

(1) Dana's Syst. of Mineral. 3rd edit. 683.

(2) Beiträge z. Metallurgischen Krystallkunde, 35 (reprinted from the 4th vol. of the Abhandl. der Kön. Gesellsch. d. Wissenschaften zu Göttingen); see p. 17 of this Report.

(3) Zeitschr. d. Deutsch. Geolog. Gesellsch. II, 136.

(4) Dana's Syst. of Mineral. 3rd edit. 696.

Silicate of  
manga-  
nese  
(Rhodo-  
nite).

**Silicate of Manganese (Rhodonite).**—Ulrich(1) has analyzed silicate of manganese of a perfectly lamellar structure from the upper Gabbro-quarry of the Radauthal in the Hartz; and A. Schlieper(2) has analyzed the same mineral (rhodonite) from Cummington in Massachusetts, after freeing the specimen, by treatment with hydrochloric acid, from an admixture of 9·85 per cent of carbonates :

|     | SiO <sub>3</sub> . | MnO.  | FeO. | MgO.  | CaO. | Al <sub>2</sub> O <sub>3</sub> . | CO <sub>2</sub> . | HO.  | Total. |
|-----|--------------------|-------|------|-------|------|----------------------------------|-------------------|------|--------|
| I.  | 44·07              | 38·39 | 4·86 | 4·85  | —    | 4·20                             | 2·34              | 1·26 | 99·97  |
| II. | 51·21              | 42·65 | 4·34 | trace | 2·93 | —                                | —                 | —    | 101·13 |

No. I, after abstraction of 3·78 per cent of MnO calculated as carbonate, makes the oxygen-ratio of RO : SiO<sub>3</sub> : Al<sub>2</sub>O<sub>3</sub> = 3·0 : 7·16 : 0·60, from which the mineral appears to be a mixture of rhodonite, manganese-spar (diallogite), and an aluminous silicate of the composition Al<sub>2</sub>O<sub>3</sub>, 2 SiO<sub>3</sub>.

**Bronzite (Diallage).**—Delessé(3) has examined an augitic mineral from the serpentine of Houx in the Vosges. It occurs there in strongly translucent, light olive-green elongated foliæ, less perfectly cleavable than bronzite parallel to  $\infty F \infty$  and  $(\infty P \infty)$ , and only cleavable in traces parallel to OP. It possesses a pearly lustre, and a spec. grav. of 3·154. The analysis, in which the magnesia was determined as "loss," gave the annexed results:

| SiO <sub>3</sub> . | Cr <sub>2</sub> O <sub>3</sub> , Mn <sub>2</sub> O <sub>3</sub> . | FeO. | MgO.  | CaO. | Loss by ignition. | Total. |
|--------------------|-------------------------------------------------------------------|------|-------|------|-------------------|--------|
| 56·33              | 1·50                                                              | 6·73 | 31·93 | 1·40 | 2·11              | 100·00 |

The oxygen-ratio deduced from this, for RO : SiO<sub>3</sub> = 1 : 2·05. Although the mineral does not possess the pseudo-metallic lustre and tombac-brown colour of bronzite, yet Delessé places it with this species on account of its high amount of magnesia.

**Breislakite.**—E. J. Chapman(4) has shown—from an examination of an extremely small, but at the same time, distinctly formed and reflecting crystal, found by him in a cellular cavity in the lava of the Capo di Bove—that the breislakite belongs, by its form and angles, not to hornblende, as conceived by many mineralogists, but to augite. This crystal possessed the general configuration of the basaltic augites, namely :  $\infty P [=D$  in Chapman's notation],  $\infty P \infty [=M]$ ,  $(\infty P \infty) [=L]$ ,  $P \infty [=P$  of Chapman, in his assumed position], and  $P [=E, id.]$  The measured angles were as follows :  $P \infty : \infty P \infty = 106^\circ 18'$ ,  $P \infty : (\infty P \infty) = 90^\circ$ ,  $P \infty : \infty P = 100^\circ 34'$ , and  $\infty P$ , in the clinodiagonal principal section =  $87^\circ 10'$ . In other respects, the crystal exhibited the same physical characters and comportment before the blow-pipe, as the capillary breislakite from the

(1) Jahrb. Miner. 1850, 683.

(2) Dana's Syst. of Mineral. 3rd edit. 463; see Report for 1849, III, 520.

(3) Ann. Min. [4] XVIII, 318; Zeitschrift d. Deutsch. Geolog. Gesellsch. II, 481.

(4) Phil. Mag. [3] XXXVII, 444; Sill. Am. J. [2] XI, 226 (in abstr.)

same cavity. It fused to a shining and but slightly magnetic bead of the same golden-brown colour as the unaltered mineral. Not a trace of copper was present, as already shown to be the case by Rammelsberg(1) and Dana(2); but, on the other hand, by fusion with carbonate of soda, a minute quantity of manganese was detected. The small fibres were not attacked by boiling hydrochloric acid.

**Hudsonite.**—W. H. Brewer(3) has analyzed a specimen of Beck's hudsonite (a black variety of augite with green streak) having a spec. grav. of 3.46.

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | FeO.  | MnO. | CaO.  | Total. |
|--------------------|----------------------------------|----------------------------------|-------|------|-------|--------|
| 36.94              | 11.22                            | trace                            | 36.03 | 2.24 | 12.71 | 99.14  |

**Ægyrine.**—According to A. Breithaupt(4), the mineral named aigirin or ægyrin by Esmark, consists of two distinct species. One of these, according to Plantamour's examination, belongs to hornblende; and the other, according to Breithaupt's own researches, to augite. The latter occurs in close association with leucophane and oligoclase, in the island of Skaadön in Brevig Bay. Its characters are stated by Breithaupt as follows:—Crystals consisting of reed-like prisms, strongly striated longitudinally, with  $\infty P : \infty P = 133^{\circ} 26'$ , from which it follows that  $\infty P$ , in the clinodiagonal principal section  $= 86^{\circ} 52'$ ; cleavage, very perfect parallel to the brachydiagonal, tolerably so parallel to the macrodiagonal, and in traces parallel to  $\infty P$ ; lustre, vitreous; colour, leek-green to greenish-black; streak, light greenish-grey; translucent at the edges; hardness = 7 to 7.5 ( $= 5$  to 5.5 according to the scale of Mohs); spec. grav. = 3.432 to 3.504. The black variety, to which the preceding description refers, contains, according to an incomplete examination by Plattner, 52.00 per cent of silica, 2.20 of alumina, and 29.25 of protoxide of iron (FeO). The loss is mostly soda. Neither potassa, lime, nor magnesia was present.

**Hornblende.**—Two varieties of crystallized hornblende—one (I) from the diabase of the Chalanches d'Allemont, and the other (II) from a similar rock in the environs of Bourg d'Oisans—have been found by Lory(5) to possess the following composition:

|     | SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO. | CaO. | MgO. | KO, NaO.* | Loss on ignition. | Total. |
|-----|--------------------|----------------------------------|------|------|------|-----------|-------------------|--------|
| I.  | 45.3               | 8.0                              | 25.7 | 12.3 | 6.0  | 1.3       | 1.4               | 100.0  |
| II. | 50.9               | 4.9                              | 21.2 | 11.2 | 8.7  | 1.5       | 1.6               | 100.0  |

\* The alkalis were determined as "loss."

(1) Rammelsb. Handwörterb. 1, Suppl. 32.

(2) Dana's Syst. of Mineral. 3rd edit. 276.

(3) Sill. Am. J. [2] IX, 228; Dana's Syst. of Mineral. 3rd edit. 269; see Beck's Rep. on the Min. of the State of New York, I, 405.

(4) Pogg. Ann. LXXX, 314; Sill. Am. J. [2] XI, 226 (in abstr.)

(5) Bull. Geolog. [2] VII, 541, 544.

Wood-  
asbestos.

**Wood-asbestos.**—L. C. Beck(1) has analyzed wood-asbestos of a greenish colour, from Staten Island :

| SiO <sub>2</sub> . | MgO.  | Fe <sub>2</sub> O <sub>3</sub> . | HO.  | Total. |
|--------------------|-------|----------------------------------|------|--------|
| 55.20              | 30.73 | 11.82                            | 2.25 | 100.00 |

**Olivine.**—J. Domqyko(2) has examined a specimen of olivine from the lava of the Antuco volcano in the Andes. The specimen was readily decomposed even by cold acids. It contained 40.70 per cent of silica, 39.7 of magnesia, and 19.6 of protoxide of iron (FeO). In physical characters it resembled the olivine of the meteoric iron of Atacama, with which it agreed also pretty closely in composition. The latter yielded: silica 40.0, magnesia 46.7, protoxide of iron 13.3:

**Anhydrous Silicates of RO and R<sub>2</sub>O<sub>3</sub>. Epidote.**—Drapiez(3) has examined green epidote (I) from the oligoclase-porphry of Quenast in Belgium; and Lory(4) has also analyzed pale yellowish-green transparent needles of the same mineral from the diabase of the Chalanches d'Allemont (II).

|     | SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO. | MnO. | CaO. | HO. | Total. |
|-----|--------------------|----------------------------------|------|------|------|-----|--------|
| I.  | 34.6               | 26.0                             | 17.0 | 1.0  | 19.0 | 3.0 | 100.0  |
| II. | 40.3               | 30.2                             | 11.2 | —    | 17.7 | —   | 99.7   |

**Allanite (Orthite).**—H. Credner(5) has discovered a rich locality of allanite at the Black Krux near Schmiedefeld in the Thüringer-Wald. It occurs there in a coarse-grained kind of granite—partly in the amorphous state, partly foliated-granular, and partly in imperfect crystals an inch, or less in size—accompanying magnetite, pyrites, molybdenite, axinite, hornblende, calc-spar, and fluor-spar. The crystals have the form of six-sided prisms, with 4 angles of about 116°, and 2 of 128°. By comparing a perfectly-formed and smooth crystal, which could not be measured, however, on account of its intimate union with the compact variety, with a similarly-formed crystal of epidote, Credner made out the planes  $\infty P \infty$ ,  $-3 P \infty$ ,  $P \infty$ ,  $-P \infty$ ,  $0 P$ ,  $P$ , and  $-P$ (6). The crystals, as in epidote, are strongly striated in the direction of the orthodiagonal; and the planes  $P$  and  $-P$  have also striæ parallel to the orthodiagonal polar edges. Fracture, between uneven and conchoidal; cleavage indistinct; opaque; lustre, vitreo-resinous; colour, deep black; and streak, greenish-black. The colour of the powder is greenish-grey inclining to brownish-yellow. Hardness=5 to 5.5, spec. grav.=3.787 to 3.792.

(1) Beck's Report on the Mineral. of the State of New York, No. 3, 1850, 132; Dana's Syst. of Mineral. 3rd. edit. 692 (in abstr.)

(2) Ann. Min. [4] XIV, 187; Jahrb. Miner. 1850, 810 (in abstr.)

(3) Brüssel. Acad. Ber. June 1, 1850; Instit. 1850, 292 (in abstr.)

(4) Bull. Géol. [2] VII, 543.

(5) Pogg. Ann. LXXIX, 144; Sill. Am. J. [2] X, 251.

(6) See Annual Report for 1847 and 1848, II, 402.

In the bulb-tube, it gives off a little water. Before the blow-pipe, it does not exhibit the glow-phenomenon, but fuses with slight intumescence into a black, shining bead. With microcosmic salt it gives, in both flames, a brownish-yellow glass, which becomes colourless on cooling, and contains a floating "skeleton" of silica. With carbonate of soda on platinum-foil, a feeble reaction of manganese is exhibited. Not decomposed in hydrochloric acid. The analysis, conducted according to Scheerer's method(1), gave the following results:

Allanite  
(Orthite).

|     | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | LaO.  | CeO. | YO.   | FeO.  | MnO.  | CaO.  | MgO. | H <sub>2</sub> O. | Total. |
|-----|--------------------|----------------------------------|-------|------|-------|-------|-------|-------|------|-------------------|--------|
| I.  | 36.82              | 16.94                            | 13.32 |      | 17.11 | 0.56  | 11.84 | 0.86  | 0.28 | 100.73            |        |
| II. | 37.55              | 15.99                            | 9.30  | 3.19 | 0.56  | 16.83 | 0.23  | 13.60 | 0.22 | 1.80              | 99.27  |

Credner makes the oxygen-ratio of  $RO : R_2O_3 : SiO_3 = 3 : 2 : 6$  (it is strictly  $= 3 : 2.33 : 6.22$ ); whilst Scheerer's analysis of the allanite of Jotun-Fjeld yielded for the same,  $3 : 2 : 5$ . The specimen employed in analysis II, was previously freed, by digestion in diluted hydrochloric acid, from admixed calcareous spar. Its spec. grav. was 3.787.

Rammelsberg(2) has distinguished as a variety of orthite a black, amorphous mineral of resinous lustre, from East Bradford in Chester County, Pennsylvania. It was sent to him by Dana. Fracture, flat-conchoidal; brittle; spec. grav. = 3.535. Before the blow-pipe, it intumescences strongly, curls up into a vermiform mass, and fuses to a blackish-brown bead. The glow-phenomenon is not developed. In hydrochloric acid, decomposition readily takes place, with gelatinization.

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | FeO.  | CeO.  | LaO. | CaO.  | MgO. | Loss on<br>ignition. | Total. |
|--------------------|----------------------------------|----------------------------------|-------|-------|------|-------|------|----------------------|--------|
| 31.86              | 16.87                            | 3.58                             | 12.26 | 21.27 | 2.40 | 10.15 | 1.67 | 1.11                 | 101.17 |

Rammelsberg particularly points out that this orthite, as well as the orthite from Miask analyzed by him at an earlier period(3), possesses the chemical constitution of the garnet, and thus sufficiently proves that the water, sometimes present, is not essential. It should be remarked, however, that the oxygen-ratio, deduced from the above analysis, of  $RO : R_2O_3 : SiO_3 = 3 : 2.75 : 5.09$ , and does not therefore strictly agree with the garnet formula.

**Manganese-Idocrase.**—M. Websky(4) has described an idocrase containing a large amount of protoxide of manganese in place of lime and protoxide of iron. It occurs at St. Marcell in Piedmont, imbedded, with manganese-epidote (withamite), in quartz. It is either in granular masses, or in crystals, in which the form

(1) Pogg. Ann. LI. 407, 465.

(2) Pogg. Ann. LXXX, 285; Sill. Am. J. [2] XI, 228.

(3) See Annual Report for 1849, III, 521.

(4) Pogg. Ann. LXXIX, 166; Jahrb. Miner. 1851, 89; Sill. Am. J. [2] X, 251.

Garnet

$\infty$  P,  $\infty$  P  $\infty$ , and P, prevail. Its colour is sulphur-yellow, or rich honey-yellow in the transparent specimens. A very minute quantity of the mineral produces, with borax before the blow-pipe, a deep amethyst-red glass, which, by treatment with tin in the reducing-flame, exhibits a feeble non-reaction. An analysis is still wanted.

**Garnet.**—Delesse(1) has analyzed a reddish, distinctly cleavable, transparent, and somewhat resinous-looking garnet, from the serpentine of Naouel in the Vosges: spec. grav. = 3.15; hardness = 6.5. Fusible before the blow-pipe, with some difficulty, to a greenish-grey glass. Effervescing feebly in acids.

| SiO <sub>3</sub> | Al O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | Ca O <sub>3</sub> | MgO   | CaO  | Loss on ignition | Total. |
|------------------|-------------------|--------------------------------|-------------------|-------|------|------------------|--------|
| 41.56            | 19.84             | 10.17                          | 0.35              | 22.00 | 4.25 | 1.58             | 99.75  |

The analysis leads to the known formula  $3\text{RO}, \text{SiO}_3 + \text{Al}_2\text{O}_3, \text{SiO}_3$ . Delesse considers that this garnet belongs to pyrope, on account of its low degree of hardness and specific gravity, combined with the presence of chromium, and with the large amount of magnesia which its analysis exhibited. Pyrope, however, as hitherto found, possesses no cleavage.

**Nepheline.**—Heidepriem(2) has analyzed the white massive nepheline from the nepheline-dolomite of the Lobau mountain:

| SiO <sub>3</sub> | Al O <sub>3</sub> | Fe <sub>2</sub> O | CaO  | MgO  | NaO   | KO   | H <sub>2</sub> O | Total  |
|------------------|-------------------|-------------------|------|------|-------|------|------------------|--------|
| 43.50            | 32.33             | 1.12              | 3.55 | 0.11 | 14.13 | 5.03 | 0.32             | 100.39 |

**Orthoclase.**—C. G. Gmelin(3) has analyzed two feldspars from the zecon-syenite of Southern Norway. The one (I), of a pale greenish-grey colour, and 2.587 spec. grav. at 12°, from the Reverban near Laurvig, where it occurs in close association with elæolite, and accompanied by natrolite.—The other (II), with a cerulean-blue opalescence, and of 25.90 spec. grav., from Frederiksværn. This latter was the variety analyzed by Klaproth.

|    | SiO <sub>3</sub> | Al O <sub>3</sub> | Fe O <sub>3</sub> | CaO   | NaO   | KO    | Volatile matter | Total.  |
|----|------------------|-------------------|-------------------|-------|-------|-------|-----------------|---------|
| I  | 65.903           | 19.463            | 0.440             | 0.275 | 6.141 | 6.552 | 0.121           | 98.895  |
| II | 65.186           | 19.989            | 0.630             | 0.481 | 7.081 | 7.029 | 0.379           | 100.775 |

The oxygen-ratio, deduced from No. I, of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 = 1 : 3.3 : 12.6$ , and that from No. II =  $1 : 3.0 : 10.9$ . Gmelin had anticipated that soda would be found in these feldspars, from their association with minerals containing that alkali; and it is his opinion that all feldspars which exhibit similar ratios to the above, contain soda; but without necessarily belonging to the inclined crystallographic systems.

(1) Ann Min [4] XVIII, 309; Zeitschr. d. Deutschen Geolog. Gesellsch. II, 429.

(2) J. Pr. Chem. L, 509; Zeitschrift d. Deutschen Geolog. Gesellsch. II, 150 (in abstr.)

(3) Pogg. Ann. LXXXI, 311.

**Loxoclase?**—Two other feldspars, from the syenite-porphry of Southern Norway, likewise remarkable for the high amount of soda which they contain, as well as for the simplicity of their forms, and their peculiar twin-structure, have been described by G. Rose(1). Their crystallization, from approximate measurements of cleavage-angles, appears to be monoclinometric: and the only planes exhibited in addition to  $\infty P$ ,  $2P \infty$  are  $OP$ ; the latter, however, in very subordinate development. The form ( $\infty P \infty$ ) is entirely wanting, on which account, the cleavage-planes of these crystals appear in the shape of rhombs or rhomboids upon the fractured surface of the rock. This led von Buch to distinguish the latter by the name of rhombic-porphry. In the twin-crystals, the line of junction is parallel to the position of  $\infty P \infty$ , similar to that of the augite forms.—One of these feldspars (I a, b), a specimen from Laurvig, was analyzed, at the request of G. Rose, by Kern. It possessed a greyish-white colour, strong translucency, pearly luster on the cleavage planes, and a spec. grav. of 2.615. A bluish opalescence was also exhibited parallel to  $\infty P \infty$  or  $2P \infty$ .—The other (II), the precise locality of which was not reported, was analyzed by L. Svanberg.—The specimen employed in analysis I a, was decomposed by means of hydrofluoric acid; and that employed in I b, by fusion with carbonate of soda.

Loxoclase?

|             | SiO <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | CaO  | MgO    | NaO    | KO   | H <sub>2</sub> O | Total |
|-------------|------------------|--------------------------------|--------------------------------|------|--------|--------|------|------------------|-------|
| Ia. (62.89) | 21.24            | 1.12                           | 1.64                           | 0.97 | 6.11   | 5.75   | —    | —                | 99.72 |
| Ib. 62.89   | 21.38            | 0.81                           | 2.29                           | 0.36 | (6.11) | (5.75) | —    | —                | 99.59 |
| II. 59.76   | 19.60            | 2.88                           | 4.37                           | 1.04 | 6.85   | 2.75   | 1.00 | —                | 98.25 |

No. I makes the oxygen-ratio in  $RO : R_2O_3 : SiO_3 = 1 : 3 : 9.8$ ; whilst that derived from No. II =  $2.5 : 16$ —G. Rose leaves it undetermined whether these feldspars—with which also he places the variety from Tyveholm near Chiusdania, considered by Delesse to be labradorite(2)—belong to loxoclase or to orthoclase. He considers it, however, probable that specimens entirely freed from the matrix would give the formula of the latter.

**Albite.**—An analysis of an albite from the phonolite of Langafiall, not far from the Great Geyser in Iceland has given Damour(3) the following results:

| SiO <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | CaO  | NaO  | KO   | Total |
|------------------|--------------------------------|--------------------------------|------|------|------|-------|
| 66.54            | 19.01                          | 1.43                           | 0.84 | 9.63 | 1.52 | 98.97 |

The oxygen-ratio in  $RO : R_2O_3 : SiO_3$ , calculated from the above, =  $1 : 3.12 : 11.82$ .

**Hypoclase.**—Rammelsberg(4) has analyzed a specimen of

(1) Zeitschrift d. Deutschen Geolog. Gesellsch. I, 378—381

(2) See Annual Report for 1847 and 1848, II, 410.

(3) Bull. Géol. 1850 [2] VII, 89; Jahrb. Miner. 1850, 349 (in abstr.)

(4) Pogg. Ann. LXXIX, 305; Jahrb. Miner. 1850, 849; Arch. Ph. Nat. XIV, 156; Phil. Mag. [3] XXXVII, 237; Sil. Am. J. [2] X, 250.



Hypo-  
sclerite.

hyposclerite, received a long time previously from Breithaupt himself, and has obtained results altogether different from those of Hermann(1). He found the spec. grav.=2.63 to 2.66. The mean of three analyses gave the following composition :

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO. | MgO. | NaO.  | KO.  | Loss on ignition. | Total. |
|--------------------|----------------------------------|----------------------------------|------|------|-------|------|-------------------|--------|
| 67.62              | 16.59                            | 2.30                             | 0.85 | 1.46 | 10.24 | 0.51 | 0.69              | 100.26 |

According to this, the oxygen-ratio is RO : R<sub>2</sub>O<sub>3</sub> : SiO<sub>3</sub> = 1.25 : 3 : 12.5. Rammelsberg makes it = 1 : 3 : 12, and considers the mineral to be an albite containing an admixture of 5.13 per cent of augite, the excess of silica, protoxide of iron, lime, and magnesia, corresponding to the composition of the latter. No trace was found of either cerium or lanthanum.

**Oligoclase.**—Delesse has examined the following varieties of oligoclase: (I), pale greenish-white twin-crystals with fine striæ(2), from the dark-green porphyry of Quenast in Belgium; (II), small ~~rose-red~~ twin-crystals of 2.69 spec. grav.(3), from an ancient red porphyry; (III), translucent greyish-green granules, without any apparent cleavage, from the variolite of Durance near Mont-Genève, not far from Briançon(4): spec. grav.=2.923; (IV), greyish-white striated compound-crystals, from the kersantite of Visembach in the Vosges(5).

|      | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | MnO.  | Cr <sub>2</sub> O <sub>3</sub> . | CaO. | MgO.  | KO.  | NaO. | Loss on ignition. | Total. |
|------|--------------------|----------------------------------|----------------------------------|-------|----------------------------------|------|-------|------|------|-------------------|--------|
| I.   | 63.70              | 22.61                            | 0.53                             | trace | —                                | 1.44 | 1.20  | 2.81 | 6.15 | 1.22              | 99.69  |
| II.  | 58.92              | 22.19                            | 0.75                             | 0.60  | —                                | 5.53 | 1.87  | 0.93 | 6.93 | 1.64              | 99.66  |
| III. | 56.12              | 17.40                            | 7.79                             | trace | 0.51                             | 8.71 | 3.41  | 0.24 | 3.72 | 1.93              | 99.86  |
| IV.  | 63.88              | 22.27                            | 0.51                             | —     | —                                | 3.45 | trace | 1.21 | 6.66 | 0.70              | 98.68  |

The oxygen-ratio of RO : R<sub>2</sub>O<sub>3</sub> : SiO<sub>3</sub>, in No. I, = 0.81 : 3 : 9.65, and the excess of silica probably indicates, according to Delesse, that the basis of the Quenast porphyry contains granular quartz. No. II makes the oxygen-ratio in the above constituents = 1.2 : 3 : 8.73; and this, in No. III, = 1.39 : 3 : 8.52, or 1 : 2.1 : 6.1, so that the latter mineral may perhaps belong to labradorite, if it be really a feldspar, a point considered doubtful by Delesse, on account of the large amount of sesquioxide of iron, and the feeble quantity of alumina, present in its composition. No. IV makes the oxygen-ratio, as above, = 0.827 : 3 : 9.633.

(1) Annual Report for 1849, III, 530.

(2) Ann. Min. [4] XVIII, 103; Bull. Géol. [2] VII, 310; Brüssel. Acad. Ber. June 1, 1850; Instit. 1850, 291 (in abstr.); Sill. Am. J. [2] XI, 226; Jahrb. Miner. 1851, 169.

(3) Ann. Ch. Phys. [3] XXX, 81; Bull. Géol. [2] VII, 525.

(4) Ann. Min. [4] XVII, 119; Bull. Géol. [2] VII, 427; Instit. 1850, 185 (in abstr.); Compt. Rend. XXX, 741; Arch. Ph. Nat. XV, 64; Sill. Am. J. [2] XI, 227.

(5) Bull. Géol. [2] VII, 705; Ann. Min. [4] XIX, 165; Arch. Ph. Nat. XVI, 240 (in abstr.)

**Chesterlite.**—To oligoclase may also belong a feldspar from the "Poorhouse" Dolomite Quarry, in Chester County, Pennsylvania, described under the name of chesterlite by T. F. Seal(1), and analyzed by H. Erni. It occurs in short and thick triclinic crystals of the albite form, with smooth but dull planes, of a white or reddish colour. The observed forms were  $\infty P' . \infty P . \infty \bar{P} \infty . 0 P . \bar{P} \infty$ , possessing the following angles, as taken by the hand-goniometer:  $\infty P' : \infty P = 124^\circ$  to  $126^\circ$ ,  $0 P : \infty P' = 110^\circ$ ,  $0 P : \infty P = 115^\circ$ ,  $\bar{P} \infty : \infty P' = 114^\circ \frac{1}{2}$ ,  $P \infty : \infty P = 112^\circ$ . It often exhibits a twin crystallization parallel to  $0 P$ , and is perfectly cleavable, both parallel to  $0 P$  and to  $\infty \bar{P} \infty$ . Hardness=6, spec. grav. (according to Silliman, Jun.) =2.513. The analysis yielded:

Chester-  
lite

| $SiO_2$ | $Al_2O_3$ | MgO. | CaO. | NaO.  | KO.  | Total. |
|---------|-----------|------|------|-------|------|--------|
| 65.56   | 18.45     | 2.09 | 0.71 | 10.41 | 2.81 | 100.08 |

Erni calculates from this, the same formula as that given by Kerndt, according to his analysis(2), for the leek-green feldspar from Bodenmais.

**Andesine.**—The three following feldspars, analyzed by Lory(3), and referred by him to andesine, may also belong to oligoclase. The first (I) occurs in small, milk-white, and scarcely translucent crystals, of a lustre between resino-vitreous and pearly, in the diabase of the Chalanges d'Allemont (Oisans); the second (II), of which no description is given, in a similar rock in the environs of Bourg d'Oisans; and the third (III), in the euphotide of Lavaldens, near La Mure (Isère). This last resembled andesine in cleavage and other external characters, amongst which Lory especially cites lustre and colour.

|      | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO. | MgO.  | NaO. | KO. | HIO. | Total. |
|------|---------|-----------|-----------|------|-------|------|-----|------|--------|
| I.   | 59.4    | 24.2      | 0.6       | 3.7  | trace | 7.0  | 3.4 | 1.18 | 99.78  |
| II.  | 59.9    | 25.1      | trace     | 3.7  | 0.7   | 7.4  | 1.2 | 1.7  | 99.7   |
| III. | 60.0    | 23.8      | 1.1       | 6.0  | 1.5   | 5.3* | 2.3 |      | 100.0  |

\* Determined from the loss.

The oxygen-ratio of  $RO : R_2O_3 : SiO_2$ , deduced from No. I, =1:3.3:9.1. That from No. II=1:3.4:9.2, and that from No. III, of  $R_2O_3 : SiO_2$ , =3:8.3.

**Spodumene.**—Eben Weeks has made the remarkable discovery, in a quartz vein in mica slate, near Norwich, in Massachusetts, of perfectly formed crystals of spodumene. Some of these are from  $\frac{1}{2}$  inch to 4 inches broad, and a foot in length. They occur imbedded in albite or orthoclase, and accompanied by mica, beryl, black and blue tourmalines, and triphylite (see the description of this latter, farther on). Their colour is principally a fine dove-brown, and

(1) Dana's Syst. of Mineral. 3rd edit. 678.

(2) See Annual Report for 1847 and 1848, II, 409.

(3) Bull. Géol. [2] VII, 542, 544, 545.

podu-  
mene.

most of them are translucent; some, indeed, are often almost transparent.—According to the description of C. Hartwell and E. Hitchcock(1), and that of J. D. Dana(2), the crystals belong to the monoclinometric system, and exhibit combinations of  $\infty P \infty$ . ( $\infty P \infty$ ).  $\infty P . P . 2 P . (2 P \infty)$ , and  $0 P$ ; to which may frequently be added, as subordinate forms, ( $\infty P 3$ ) and  $n P m$ . The following are the most important angles, as measured by Dana with the hand-goniometer.  $\infty P = 87^\circ$ ,  $P = 117^\circ$ ,  $(2 P \infty) = 79^\circ 30'$ , all in the clinodiagonal principal section;  $\infty P \infty . 0 P = 69^\circ 40'$ ;  $\infty P \infty : (\infty P 3) = 107^\circ$ ;  $\infty P \infty . P = 100^\circ 30'$ ;  $\infty P \infty . 2 P = 116^\circ$  and  $\infty P \infty . (2 P \infty) = 106^\circ - 107^\circ$ . (From the angles of  $\infty P$ ,  $(2 P \infty)$  and  $\alpha$ , the ratio of orthodiagonal to clinodiagonal, to axis  $c$  would be  $1 : 1.23 : 0.458$ ). Cleavage perfect, parallel to  $\infty P \infty$ ; less perfect, parallel to  $\infty P$ ; and indistinct in a third direction parallel to  $m P$ , as indicated by delicate striæ, on the surface of  $\infty P \infty$ , running parallel to the combination-edges of  $\infty P \infty$  and  $P$ .

J. Brück(3) has analyzed the spodumene described above (Ia and b), as well as other specimens from Sterling (IIa and b), and he has obtained the following results:

|      | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO  | LiO  | NaO  | Total  |
|------|------------------|--------------------------------|------|------|------|--------|
| Ia   | 63.06            | 28.00                          | 0.95 | 5.67 | 2.51 | 100.19 |
| b    | 62.72            | 28.85                          | 1.13 | 5.67 | 2.51 | 100.88 |
| IIa  | 62.86            | 28.83                          | 0.56 | 6.18 | 1.76 | 100.19 |
| b    | 62.67            | 29.83                          | 0.71 | 6.18 | 1.76 | 101.45 |
| Mean | 62.82            | 28.88                          | 0.51 | 6.07 | 2.17 | 100.78 |

The oxygen-ratio of  $RO : R_2O_3 : SiO_2$ , from the mean of these analyses,  $= 1 : 3.27 : 7.92 = 1 : 3 : 8$ , leading to the common formula  $3 RO, 2 SiO_2 + 3 (Al_2O_3, 2 SiO_2)$ , which is also that of leucite and andesine.

**Labradorite**—Damou(4) has analyzed yellowish crystallized labradorite (I), of 2.709 spec. grav., from the decomposed basalt of Diupavog, near Berufjord, on the east coast of Iceland; and E. Metzger(5), a similar kind (II) from weathered diabase-porphry from the Hutthal, near Clausthal.

|     | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | FeO  | CaO   | NaO  | KO   | HO   | Total |
|-----|------------------|--------------------------------|------|-------|------|------|------|-------|
| I.  | 52.17            | 29.22                          | 1.90 | 13.11 | 3.40 | —    | —    | 99.80 |
| II. | 54.44            | 25.50                          | 5.33 | 8.05  | 2.11 | 0.12 | 3.65 | 99.20 |

The oxygen-ratio, deduced from No. I, of  $RO : R_2O_3 : SiO_2 = 1 : 3.07 : 5.98$ , or almost exactly the proportions required by the formula  $RO, SiC_3 + Al_2O_3, SiO_2$ . The labradorite No. II yielded, for the above ratio,  $1 : 4.71 : 10.07$ , and was already, therefore, considerably decomposed, as shown, furthermore, by the large amount of water which it contained.

(1) Sil. Am. J. [2] X, 264.

(2) Sil. Am. J. [2] X, 119; Dana's Syst. of Mineral. 3rd edit. 693.

(3) Sil. Am. J. [2] X, 370—383.

(4) Bull. Géol. [2] VII, 88, Jahrb. Miner. 1850, 347 (in abstr.)

(5) Jahrb. Miner. 1850, 683.

**Anorthite.**—Damour(1) has also examined some transparent vitreous granules, of 2.75 spec. grav., from the vesicular lava of Thjorsa. These fuse before the blow-pipe into an enamel; and are decomposed, with separation of silica by hydrochloric acid. Besides the silica, a feeble residue is also left; and Damour believes this to originate from augite. The mean of two analyses gave the following composition:

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO.  | NaO. | Residue. | Total. |
|--------------------|----------------------------------|----------------------------------|-------|------|----------|--------|
| 45.97              | 33.28                            | 1.12                             | 17.21 | 1.85 | 0.69     | 100.12 |

This makes the oxygen-ratio of RO :  $R_2O_3$  : SiO<sub>3</sub> = 1 : 2.94 : 1.51. Damour regards the mineral as anorthite, a conclusion favoured by the complete concordance of the above results with those obtained by Forchhammer in his analysis of anorthite from Selfjäll(2), as well as by the capability, exhibited by the mineral, of being decomposed in acids. Damour also refers to anorthite the thjorsauite of Genth(3); but, in opposition to this, it should be remembered that the latter mineral is not affected by acids.

**Atherlastite (Wernerite).**—P. H. Weibye(4) has distinguished, under the name of atheriastite, an opaque, verdigris-green mineral, previously considered to be a variety of scapolite, from the "Näs" Iron Mine, near Arendal; where it occurs in association with black garnet and keilhauite, in a granitic rock. It exhibits short thick crystals of the tetragonal (dimetric) system, the edges and angles of which appear to be rounded. The forms  $\infty P$ ,  $\infty P \infty$ , and  $P$  were observed; the latter measuring over the polar edges about  $135^\circ$ . The crystals are perfectly cleavable parallel to  $\infty P \infty$ ; dull, on the uneven splintery fracture; and greenish-grey in the streak. Before the blow-pipe they exfoliate parallel to the prismatic planes, and fuse easily to a dark-brown glass. Even in the finest powder, the mineral is scarcely attacked by hydrochloric acid. An analysis, performed by Berlin, yielded:

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | CaO.  | MgO. | FeO. | MnO. | VO.  | Total. |
|--------------------|----------------------------------|-------|------|------|------|------|--------|
| 38.00              | 24.10                            | 22.64 | 2.80 | 4.82 | 0.78 | 6.95 | 100.09 |

Berlin did not determine whether the iron was present in the state of protoxide only, or partly in that of sesquioxide. On the former supposition, he calculates the formula  $4(3 RO, SiO_3) + 5(Al_2O_3, SiO_3) + 9 HO$ ; and on the latter,  $2(3 RO, SiO_3) + 3(Al_2O_3, SiO_3) + 4 HO$ . He considers this second formula to be the more probable of the two.

According to J. F. L. Hausmann(5), the atheriastite is identical

(1) Bull. Géol. [2] VII, 87; Jahrb. Miner. 1850, 446 (in abstr.)

(2) J. Pr. Chem. XXX, 385.

(3) See Annual Report for 1847 and 1848, II, 407.

(4) Pogg. Ann. LXXIX, 302; Arch. Ph. Nat. XIV, 154; Phil. Mag. [3] XXXVII, 236; Sil. Am. J. [2] X, 246.

(5) Pogg. Ann. LXXX, 567.

Atherias-  
tite  
(Werner-  
ite)

with Haüy's wernerite—a mineral quite distinct from Haüy's paranthine, the scapolite of authors—and also with the dark leek-green variety of Schumacher's wernerite. He distinguishes it from scapolite—to which mineral he had himself at an earlier period referred the wernerite as a variety—partly by the general configuration of the crystals, although these belong essentially to the same crystallographic form; partly by the other external characters; and especially, by the amount of water in its composition:—On account of this latter, Hausmann justly surmises that atheriasite, for which the original name of wernerite may be retained, has the same relation to scapolite as aspidolite to iolite; and may, consequently, be merely a pseudomorph.

**Scapolite.**—W. H. Brewer (I and II), and T. H. Garrett (III), have analysed a translucent leek-green scapolite from Franklin in New Jersey (1). It was already in a decomposed state, although still distinctly cleavable. Hardness = 3.5, spec. grav. = 2.78. H. Wurtz (2) has analysed the pale-red scapolite of Bolton in Massachusetts (IV), spec. grav. = 2.700—2.701.

|     | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO   | MgO  | FeO   | KO    | NaO  | HO.  | CO <sub>2</sub> | Total. |
|-----|------------------|--------------------------------|-------|------|-------|-------|------|------|-----------------|--------|
| I.  | 55.39            | 29.09                          | 11.13 | 1.97 | 2.04  | trace | —    | 1.80 | 4.72            | 97.14  |
| II. | 48.32            | 28.44                          | 12.88 | 2.07 | 1.40  | trace | —    | 1.80 | 4.72            | 99.63  |
| III | 44.75            | 28.80                          | 8.85  | 1.50 | —     | 4.14  | 0.88 | —    | 4.55            | 93.47  |
| IV  | 47.67            | 25.75                          | 17.31 | —    | 2.26* | —     | 7.76 | —    | —               | 100.75 |

\* Fe<sub>2</sub>O<sub>3</sub>

**Castor.**—According to H. Rose (3), the mineral described by Breithaupt as a distinct species, under the name of castor, is a variety of petalite, from which it only differs by the absence of soda, and by its slightly lower spec. grav.

**Micas.**—J. D. Dana (1), in conjunction with B. Silliman, Jun., has measured the angles of the optical axes of a series of micas; and the former (5) has arranged these minerals in accordance with the results thus obtained, as well as by their oxygen-ratios, in 11 subdivisions. He reckons as muscovite, all micas in which the angles of the optical axes are from 50° to 75°; as lepidolite, all those having the same angles = 75° to 76°; and as phlogopite, a rhombic group, all in which the above angles = 7° to 18°. The first of these divisions includes most of the micas from the granitic rocks, the second comprises all the lithia-micas; whilst to the third belong, besides the micas included by Breithaupt under the name of phlogopite, many

(1) Dana's Syst. of Mineral 3rd edit. 680

(2) Sill. Am. J. [2] X, 325; respecting the method employed, see p. 404 of the present Report.

(3) Pogg. Ann. LXXIX, 162, Sill. Am. J. [2] X, 250; Arch. Ph. Nat. XIV, 61.

(4) Sill. Am. J. [2] X, 118, 372

(5) Dana's Syst. of Mineral. 3rd. edit. 356, 687; Jameson's New Edinb. Journ. L, 339

others—chiefly of a yellowish-brown colour, or often deep copper-red—from serpentine, limestone, and dolomite, in New York, Canada, and New Jersey.

W. J. Craw(1) has analyzed three varieties of mica belonging to the phlogopite division, from Edwards in St. Lawrence County, New Jersey: (I), a deep yellowish-brown, broadly-foliated variety; (II), a transparent variety, with silvery lustre; and (III), a fragment from the same specimen as No. II, but rendered opaque by the admission of a little water.—J. D. Darrack(2) has also analyzed a mica (IV) from Unionville; and W. H. Brewer(3) a specimen of margarodite, from Monroe County.

|      | SiO <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> *. | CaO. | MgO.  | KO.   | NaO. | Cl.  | Fl.   | HO.  | Total. |
|------|------------------|-----------------------------------|------|-------|-------|------|------|-------|------|--------|
| I.   | 40.14            | 17.35                             | —    | 28.09 | 10.56 | 0.63 | —    | 4.202 | )    | 100.97 |
| II.  | 40.35            | 16.45                             | —    | 29.55 | 7.22  | 4.93 | —    | 0.95  |      | 99.45  |
| III. | 40.36            | 16.08                             | —    | 30.24 | 6.06  | 4.39 | —    | 2.65  |      | 99.78  |
| IV.  | 46.75            | 39.20                             | 0.39 | 1.02  | 6.56  | —    | —    | —     | 4.90 | 98.82  |
| V.   | 49.96            | 32.85                             | —    | 1.08  | 7.91  | 2.89 | 0.14 | —     | 4.46 | 99.29  |

\* With traces of sesquioxide of iron.

Craw calculates from his analysis the formula:  $7(3RO, SiO_3) + 4(Al_2O_3, SiO_3)$ .

Rammelsberg(4) and W. Stein(5) have analyzed the lithia-mica of Zinnwald. The former employed for his analysis a coarsely-foliated variety (I), containing a little quartz in admixture; the latter, a finely-foliated specimen from the Peterszeche (II).

|     | Fl.  | PO <sub>3</sub> | SiO <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | FeO. | MnO. | MgO. | KO.  | NaO. | LiO. | Total. |
|-----|------|-----------------|------------------|--------------------------------|--------------------------------|------|------|------|------|------|------|--------|
| I.  | 7.47 | 0.13            | 46.52            | 21.81                          | 4.78                           | 6.80 | 1.96 | 0.44 | 9.09 | 0.39 | 1.27 | 100.66 |
| II. | 8.16 | —               | 48.65            | 17.67                          | —                              | 1.57 | 1.24 | 0.53 | 8.60 | 0.71 | 2.41 | 102.54 |

The formula  $RO, SiO_3 + R_2O_3, SiO_3$ , is calculated by Rammelsberg from the above. As in the case of the tourmaline (which see), Rammelsberg has also deduced for the micas the following series of fundamental combinations. He finds these divisions on oxygen-ratios, calculated by him, from the most trustworthy analyses yet known(6).

#### A. Potassa-mica.

- I.  $KaO, SiO_3 + 2(Al_2O_3, SiO_3)$
- II.  $KaO, SiO_3 + 3(Al_2O_3, SiO_3)$
- III.  $KaO, SiO_3 + 4(Al_2O_3, SiO_3)$

#### B. Lithia-mica.

- IV.  $RO, SiO_3 + R_2O_3, SiO_3$
- V.  $3(RO, SiO_3) + 2(R_2O_3, SiO_3)$
- VI.  $2(RO, SiO_3) + 3(R_2O_3, SiO_3)$

(1) Sill. Am. J. [2] X, 383.

(2) Dana's Syst. of Mineral. 3rd edit. 357.

(3) Ibid. 359.

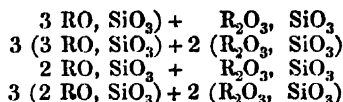
(4) Pogg. Ann. LXXXI, 43.

(5) Polyt. Centr. 1847, No. 23; Pogg. Ann. LXXXI, 43.

(6) Rammelsb. Handwörterb. 4. Suppl. 75; Pogg. Ann. LXXXI, 42.

## Emerylite.

## C. Magnesia-mica.



**Emerylite.**—In addition to a detailed description of the emerylite discovered by him in Asia Minor, L. Smith(1) has communicated a series of analyses of that mineral, from specimens taken from different localities. He first met with the substance on the emery of the Gummuchdagh; afterwards, on the emery of Naxos, Nicaria, and Manser; and finally, on a specimen of the same substance from Siberia. Naxos, a locality in which the mineral occurs in admixture with diaspore, furnishes the most beautiful emerylite. This variety is in the form of white, pearly, delicately-foliated, and very frangible masses, resembling talc. Often, also, in larger micaceous leaves of a silvery lustre, but much less elastic than mica; and these are occasionally disposed in three-sided prisms.—Judging from the two imperfect directions of the folia, combined with the striation of its planes, the emerylite may be considered to belong to the monoclinometric system. Its spec. grav. oscillates between 2·80 and 3·09. Before the blow-pipe it fuses only on the edges, and that with difficulty. It is not attacked by acids.

| Localities. | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO.  | MgO.  | HO.  | Total. |
|-------------|--------------------|----------------------------------|----------------------------------|-------|-------|------|--------|
| Gummuch     | 29·66              | 50·88                            | 1·78                             | 13·56 | 0·50  | 3·41 | 99·79  |
| Nicaria     | 30·22              | 49·67                            | 1·33                             | 11·57 | trace | 5·12 | 97·91  |
| Nicaria     | 29·87              | 48·68                            | 1·63                             | 10·84 | trace | 4·32 | 95·34  |
| Naxos       | 30·02              | 49·52                            | 1·65                             | 10·82 | 0·40  | 5·55 | 97·96  |
| Naxos       | 28·90              | 48·53                            | 0·87                             | 11·92 | —     | 5·08 | 95·30  |
| Naxos       | 30·10              | 50·08                            | —                                | 10·80 | —     | 4·52 | 95·50  |
| Gummuch     | 30·90              | 48·21                            | 2·80                             | 9·53  | —     | 4·61 | 96·05  |
| Gummuch     | 31·93              | 48·80                            | 1·50                             | 9·41  | —     | 3·62 | 95·26  |
| Siberia     | 28·50              | 51·02                            | 1·78                             | 12·05 | —     | 5·04 | 98·39  |

Smith calculates the formula  $2 \text{ RO, SiO}_3 + 2 (2 \text{ Al}_2\text{O}_3, \text{SiO}_3) + 2 \text{ HO}$  from the above. He looks upon the sesquioxide of iron as a mechanical admixture.

Specimens of the American emerylites from Village Green (I), and from Unionville (II), have been analyzed by W. J. Craw. From the latter locality (III), also, by C. Hartshorne; and from North Carolina (IV), by Silliman, Jun.(2)

|      | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | CaO.  | MgO. | KO.             | NaO. | HFl. | HO.  | Total. |
|------|--------------------|----------------------------------|-------|------|-----------------|------|------|------|--------|
| I.   | 30·18              | 51·40                            | 10·87 | 0·92 | 0·54            | 2·23 | —    | 4·52 | 100·66 |
| II.  | 29·99              | 50·57                            | 11·31 | 0·62 | 0·85            | 1·62 | —    | 5·14 | 100·10 |
| III. | 32·15              | 54·28                            | 11·36 | 0·05 | not determined. |      |      | 0·50 | —      |
| IV.  | 29·17              | 48·40                            | 9·87  | 1·24 | —               | 6·15 | 2·03 | 3·99 | 100·85 |

(1) Ann. Min. [4] XVIII, 296; Phil. Mag. [4] I, 413 (in abstr.)

(2) Dana's Syst. of Mineral. 3rd edit. 362.

These analyses lead to the following formula, as calculated by Silliman:  $3 RO, SiO_3 + 3 (2 R_2O_3, SiO_3) + 3 HO(1)$ .

**Euphyllite.**—H. Erni (I, II), and T. H. Garrett (III, IV) have analyzed the euphyllite of Unionville(2).

Euphyllite.

|            | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO.  | MgO.              | KO.   | NaO. | HO.    | Total. |
|------------|--------------------|----------------------------------|----------------------------------|-------|-------------------|-------|------|--------|--------|
| I. 43.69   | 44.69              | —                                | 3.98                             | 0.75  | 0.82              | 0.98  | 5.60 | 100.51 |        |
| II. 43.45  | 44.98              | —                                | 4.34                             | 0.69  | not determined.   |       | 4.97 | —      |        |
| III. 45.93 | 48.23              | 0.60                             | 3.53                             | 2.44  | —                 | trace | —    | 100.73 |        |
| IV. 45.33  | 46.47              |                                  | 2.36                             | trace | — not determined. |       | —    | —      |        |

From Erni's analysis, No. I, the oxygen-ratio of  $RO : R_2O_3 : SiO_3 : HO = 1.04 : 12 : 13.30 : 2.86$ . In Garrett's analysis, No. III, also, the same  $= 1.04 : 12 : 12.84$ . Both of these ratios, therefore, differ very widely from those deduced from Crooke's analysis(3).—The mineral in its normal condition is evidently anhydrous, and its formula should perhaps be written  $RO, SiO_3 + 4 (2 R_2O_3, SiO_3)$ . According to Dana, it is optically biaxial; and Silliman, Jun., gives  $71^\circ 30'$  for the angle between the axes.

**Ephesite.**—L. Smith(4) has discovered another new micaceous mineral associated with corundum. He has named this, ephesite. It occurs on magnetite, near Ephesus, in foliated masses, which are white, pearly, and easily separable in the direction of the laminae; and which, at first sight, have some resemblance to white disthene. Its spec. grav.  $= 3.15$  to  $3.20$ ; and its hardness is so high, that the mineral scratches glass with ease. It loses its polish before the blow-pipe, but does not fusc. Its analysis yielded:

|     | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | CaO. | FeO. | NaO. | HO.  | Total. |
|-----|--------------------|----------------------------------|------|------|------|------|--------|
| I.  | 31.54              | 57.89                            | 1.89 | 1.34 | —    | 3.12 | —      |
| II. | 30.04              | 56.45                            | 2.11 | 1.00 | 4.41 | 3.06 | 97.07  |

Smith calculates from the above, the formula  $2 RO, SiO_3 + 5 (2 Al_2O_3, SiO_3) + 4 HO$ ; but the second analysis makes the oxygen ratio of  $RO : R_2O_3 : SiO_3 : HO = 1 : 13.43 : 8.11 : 4.38$ , which may be fairly assumed  $= 1 : 12 : 9 : 1$ , leading to the formula  $RO, SiO_3 + 2 (R_2O_3, SiO_3) + HO$ ; or, abstracting, to that of euphyllite containing  $\frac{1}{2}$  the normal amount of silicate of alumina.

**Hydrated Silicates of  $R_2O_3$ . Kaolin from Beryl.**—Damour(5) has examined the columnar kaolin of the well-known kaolin-pits of Chanteloube. The substance of this kaolin originates from beryl, and frequently possesses not only unaltered kernels of that mineral, but also its distinct crystal form. It occurs imbedded in decomposed.

(1) See Annual Report for 1849, III, 531.

(2) Dana's Syst. of Mineral. 3rd edit. 362.

(3) See Annual Report for 1849, III, 533.

(4) Ann. Min. [4] XVIII, 294.

(5) Bull. Géol. [2] VII, 224.



Kaolin  
from  
beryl.

albite, and is of a yellowish or greyish-white colour, and infusible. It gives off water when heated in the bulb-tube; becomes dirty-blue when ignited with the cobalt-solution; and leaves by fusion with phosphorus-salt, a silica skeleton. Hydrochloric acid has only a partial action on it; but it is entirely and easily decomposed, with separation of unaltered beryl, by hot concentrated sulphuric acid. The kaolin employed for the analysis was well washed, and thus freed as much as possible from undecomposed beryl. In stating the following results, the residue is abstracted which remained after treatment with sulphuric acid. The specimen was dried at 60°.

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | BcO. | CaO.  | HO.   | Total. |
|--------------------|----------------------------------|----------------------------------|------|-------|-------|--------|
| 45·61              | 38·86                            | 0·94                             | 1·10 | trace | 14·04 | 100·55 |

Damour calculates from this analysis, the formula  $3 \text{ Al}_2\text{O}_3, 4 \text{ SiO}_3 + 6 \text{ HO}$ ; and he shows that, in the decomposition of the beryl, all the berylla, together with  $\frac{1}{4}$  of the silica, must have been carried off by the agency of water.

**Lithomarge.**—G. C. Wittstein(1) has analyzed a greyish-white lithomarge from a sandstone-quarry near Minden in Hanover. This, when first obtained, is soft and plastic; but in the dried condition it has a chalky appearance, is greasy to the touch, and falls to pieces in water with decrepitation, forming a fine slime. For analysis No. I, a fresh specimen, just taken from the quarry, was employed; whilst that on which analysis No. II was made, had been already dried by exposure to the atmosphere. Both were farther dried at 100°, before subjection to analysis.

| Sp. gr.   | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO. | MgO.  | KO.  | SO <sub>3</sub> . | HO.  | Total. |
|-----------|--------------------|----------------------------------|----------------------------------|------|-------|------|-------------------|------|--------|
| I. 2·722  | 61·20              | 20·00                            | 7·80                             | 1·80 | 0·21  | 2·02 | 0·41              | 6·30 | 99·77  |
| II. 2·683 | 61·20              | 15·60                            | 14·10                            | 0·20 | trace | 2·40 | trace             | 6·19 | 99·69  |

From analysis No. I, Wittstein calculates the formula  $2 (\text{R}_2\text{O}_3, 3 \text{ SiO}_3) + 3 \text{ HO}$ .

**Pholerite.**—L. Smith(2) has found pholerite (I), accompanying emerylite, on the emery of Naxos. It is in white or greyish crystalline folia, greasy to the touch, like steatite, and infusible before the blow-pipe. Its spec. grav. = 2·56. The analysis yielded:

|     | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | CaO.   | HO.   | Total. |
|-----|--------------------|----------------------------------|--------|-------|--------|
| I.  | 44·41              | 41·20                            | 1·21   | 13·14 | 99·96  |
| II. | 42·11              | 42·81                            | traces | 12·42 | 97·34  |

The oxygen-ratio of  $\text{Al}_2\text{O}_3 : \text{SiO}_3 : \text{HO}$ , deduced from this =  $3 : 3·6 : 1·8$ , and leads to the known formula  $\text{Al}_2\text{O}_3, \text{SiO}_3 + 2 \text{ HO}$ . It is evident that the silicate of alumina (analysis II) discovered by

(1) Repert. Pharm. [3] V, 317; Jahrb. Miner. 1851, 202 (in abstr.)

(2) Ann. Min. [4] XVIII, 293.

Smith(1) in the same locality, likewise belongs to this mineral. No characters are given beyond the composition. Allophane.

**Allophane.**—Schnabel(2) has analyzed allophane from Goldhausen near Corbach in the Principality of Waldeck, where it occurs as a verdigris-green or greenish-white amorphous coating on clay-slate. For analysis No. I, a light-coloured variety was made use of; and for No. II, a dark variety, the spec. grav. of which = 2.02.

|     | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | CuO.  | HO.   | Total. |
|-----|--------------------|----------------------------------|-------|-------|--------|
| I.  | 24.19              | 25.80                            | 13.71 | 35.19 | 99.19  |
| II. | 19.41              | 26.77                            | 18.97 | 31.72 | 99.87  |

**Nonttronite.**—Mehner(3) has analyzed light green nonttronite, of 2.337 spec. grav., from Andreasberg (I); and also a similar kind of mineral (II) which occurs with it at that locality. This latter substance is, however, black, and not completely decomposed in hydrochloric acid.

|     | SiO <sub>3</sub> . | FeO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO. | CaO.  | MgO.  | HO.   | Total. |
|-----|--------------------|--------------------|----------------------------------|------|-------|-------|-------|--------|
| I.  | 40.49              | 33.70              | 1.09                             | 2.25 | 1.11  | —     | 21.81 | 100.45 |
| II. | 46.21              | 36.32              | —                                | —    | trace | trace | 20.38 | 102.91 |

**Hydrated Silicates of RO. Meerschaum.**—X. Landerer(4) has analyzed meerschaum from Thebes:

|  | SiO <sub>3</sub> . | MgO. | Al <sub>2</sub> O <sub>3</sub> . | CaO. | HO. | Total. |
|--|--------------------|------|----------------------------------|------|-----|--------|
|  | 52                 | 30   | 2                                | 4    | 10  | 98     |

Together with traces of the sesquioxides of iron and manganese.

**Diophtase.**—Kengott(5) has found the following, hitherto unobserved, forms, in crystals of diophtase:—the hexagonal prisms of the third order  $l \frac{\infty P^4}{2}$ ,  $l \frac{\infty P^3}{2}$ , and  $r \frac{\infty P^8}{2}$ ; the trigonal trapezohedrons  $r - \frac{12 P^{12}}{4}$ , and  $l - \frac{4 P^4}{4}$ ; the scalenohedrons  $-\frac{P^2}{2}$ , and  $-\frac{16 P^{16}}{2}$ ; and the rhombohedron 2 R. The angle over the polar

edges of  $-2R$ , according to Kengott's measurement, =  $95^\circ 51'$ , and the same angle in the cleavage rhombohedron =  $126^\circ 25'$ . Spec. grav. = 3.314 to 3.348.—Kengott also observed a diophtase twin-form with the planes of union parallel to R.

**Chrysocolla.**—C. T. Jackson(6) has analyzed chrysocolla from Copper Harbour:

|  | SiO <sub>3</sub> . | CuO.  | Fe <sub>2</sub> O <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | HO.   | Total. |
|--|--------------------|-------|----------------------------------|----------------------------------|-------|--------|
|  | 37.85              | 27.97 | 8.90                             | 4.80                             | 20.00 | 99.52  |

(1) Ann. Min. [4] XVIII, 290.

(2) Verhandl. d. Naturh. Ver. d. Preuss. Rheinl. 1859 (7. Jahrg.), 4.

(3) J. Pr. Chem. XLIX, 382.

(4) Jahrb. Miner. 1850, 313.

(5) Kengott's Min. Untersuch., Part II, 93—111.

(6) Dana's Syst. of Mineral. 3rd edit. 520.

Silicate  
of zinc.

**Silicate of Zinc.**—E. Schmidt(1) has analyzed the silicate of zinc of Moresnet near Aix-la-Chapelle:

| ZnO.  | SiO <sub>3</sub> . | CO <sub>2</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | HO.  | Total. |
|-------|--------------------|-------------------|----------------------------------|------|--------|
| 66.48 | 24.44              | 1.02              | 0.72                             | 7.02 | 99.68  |

Schmidt affirms, on this occasion, that if minerals which contain carbonate of zinc be digested, after ignition, at a temperature of from 30° to 40° in a solution of carbonate of ammonia (to which a little free ammonia has been added), the carbonate of zinc is entirely dissolved out. In this manner, the admixture of zinc-spar in the silicate of zinc may be directly determined in the analysis of the latter.

**Apophyllite.**—C. T. Jackson(2) has analyzed apophyllite from the Cliff mine in Michigan. He found its spec. grav. = 2.305.

|     | SiO <sub>3</sub> . | CaO.  | KO.  | HO.   | CaFl | Total. |
|-----|--------------------|-------|------|-------|------|--------|
| I.  | 52.70              | 23.35 | 4.95 | 16.00 | 1.85 | 98.75  |
| II. | 52.00              | 24.94 | 5.19 | 16.00 | 1.94 | 99.00  |

**Hydrated Silicates of R<sub>2</sub>O<sub>3</sub> and RO. Natrolite.**—C. G. Gruner(3) has analyzed natrolite from the zircon-syenite of Laurvig. He believes it to be the "fibrous wernerite" of former observers. It occurs in radiated-crystalline, vitreous, and pale greenish-grey or colourless masses, imbedded in the soda-feldspar described at p. 490. Its spec. grav. at 11° = 2.207. It gelatinizes in hydrochloric acid, both before and after ignition—in the latter case, with extreme rapidity, and with the development of great heat. The analysis yielded the following results, corresponding exactly with the known formula NaO, SiO<sub>3</sub> + Al<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub> + 2 H<sub>2</sub>O.

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | NaO.   | KO.   | HO.   | Total.  |
|--------------------|----------------------------------|--------|-------|-------|---------|
| 48.680             | 26.369                           | 16.002 | 0.352 | 9.550 | 100.953 |

**Harringtonite and Lehuntite.**—On a specimen of harringtonite in the "Imperial Mineral Cabinet" in Vienna, Kengott(4) has observed rhombic prisms with angles of 90° 54' and 89° 6'; and also on a specimen of lehuntite, similar prisms measuring from 91° 2' to 91° 52' in the brachydiagonal principal section. He considers it very probable that both belong to natrolite.

**Antrimolite and Poonahlite.**—Kengott(5) has likewise noticed on a specimen of antrimolite, combinations of two rhombic prisms ∞ P. ∞ P̄ 4 with angles in the brachydiagonal principal section of about 92° 13' and 150° 30'. He also found on a specimen of poonahlite,

(1) J. Pr. Chem. LI, 258.

(2) Dana's Syst. of Mineral. 3rd edit. 249.

(3) Pogg. Ann. LXXXI, 312.

(4) Wien. Acad. Ber. 1860, October, 240.

(5) Ibid. 234.

similar prisms possessing a perfect  $\infty P$  cleavage, and measuring  $91^\circ 49'$  on the surface-planes, and  $91^\circ 46'$  on the planes of cleavage. As these angles closely approach those of scolezite, and as the three minerals (antrimolite, poonahlite, scolezite) agree very nearly in composition, Kengott thinks it not improbable that they constitute a single species. According to J. D. Whitney(1), Shephard's ozarkite also belongs to scolezite.

Antrimolite and poonahlite.

**Analcime.**—C. T. Jackson(2) has analyzed an analcime from Michigan :

| Spec. grav. | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | NaO. | CaO. | HO.  | Total. |
|-------------|--------------------|----------------------------------|------|------|------|--------|
| 2.25        | 53.40              | 22.40                            | 8.52 | 3.00 | 9.70 | 97.02  |

**Laumonite.**—R. Wildenstein(3) has analyzed a partially weathered laumonite from Oberscheld near Dillenburg. The specimen was dried for analysis at  $100^\circ$ .

|     | SiO <sub>3</sub> . | CO <sub>2</sub> . | CaO.  | MgO.  | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | HO.  | Total. |
|-----|--------------------|-------------------|-------|-------|----------------------------------|----------------------------------|------|--------|
| I.  | 39.12              | 13.45             | 25.18 | trace | 13.13                            | 2.60                             | 6.22 | 100.00 |
| II. | 56.33              | —                 | 11.64 | —     | 19.34                            | 3.73                             | 8.96 | 100.00 |

Abstracting the carbonic acid and an amount of lime corresponding to the composition of the carbonate, Wildenstein calculates the quantities given under No. II. These agree with the composition of a laumonite deprived by weathering of a portion of its water.

**Eudnophite.**—P. H. Weibye(4) has distinguished, under the name of eudnophite (from  $\epsilon\upsilon$  and  $\delta\nu\phi\phi\omicron\varsigma$ ) a new zeolite, which possesses the same composition as analcime, but which belongs to the rhombic system of crystallization. He found it in association with leucophane, mosandrite, and other rare minerals, in coarsely-granular syenite, on the Island of Lamö, near Brevig. The crystals are translucent to transparent on the edges; and grey, brownish-white, or indistinctly coloured. They exhibit combinations of  $\infty P . \infty \bar{P} \infty . n \bar{P} \infty$ , with the following angles:  $\infty P = 130^\circ$  (5) in the brachydiagonal principal section,  $\infty P : \infty \bar{P} \infty = 120^\circ$ , and  $n \bar{P} \infty : \infty \bar{P} = 130^\circ$ . They are perfectly cleavable parallel to  $0 P$ ; less perfectly parallel to  $\infty \bar{P} \infty$  and  $\infty \bar{P} \infty$ ; and on the cleavage-planes they possess a feeble pearly lustre. The surface-planes are dull or slightly shining, and the granular and amorphous specimens are generally strongly striated, the striæ being also sometimes plumiformly arranged. Hardness =

- (1) Sill. Am. J. [2] IX, 430; Dana's Syst. of Mineral. 3rd edit. 302 (in abstr.)  
 (2) Dana's Syst. of Mineral. 3rd edit. 311.  
 (3) Jahrb. d. Ver. f. Naturk. im Herzogth. Nassau, 6. Heft, 134.  
 (4) Pogg. Ann. LXXIX, 303; Jahrb. Miner. 1850, 703; Arch. Ph. Nat. XIV, 155; Phil. Mag. [3] XXXVII, 236; Sill. Am. J. [2] X, 246.  
 (5) This is evidently a misprint, for if the inclination of  $\infty P : \infty \bar{P} \infty = 120^\circ$ , that of  $\infty P : \infty P$  must also =  $120^\circ$ ; or, if  $\infty P = 130^\circ$ ,  $\infty P : \infty \bar{P} \infty$  must =  $115^\circ$ .

Eudno-  
phite.

5.5; spec. grav. = 2.27. The mineral fuses before the blow-pipe to a clear, colourless glass; and in the state of powder, it is decomposed with gelatinization by hydrochloric acid. Two analyses, performed by Borck (I) and by Berlin (II), gave the following results, according to which, Weibye considers the substance of analcime to be dimorphous:

|           | SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | NaO. | HO.    | Total. |
|-----------|--------------------|----------------------------------|------|--------|--------|
| I. 54.93  | 23.59              | 14.06                            | 8.29 | 100.87 |        |
| II. 55.06 | 23.12              | 14.06                            | 8.16 | 100.40 |        |

**Berzeline, Zeagonite, Abrazite, and Gismondine.**—Kengott(1) has submitted specimens of berzeline (Necker), zeagonite, abrazite, and gismondine, from the "K. K. Hof-Mineralien Cabinet," in Vienna, to a comparative examination, in order to define clearly the points of difference between these generally-confounded zeolites, the individuality of which as distinct species is doubtful. The result of his examination is as follows:—The mineral distinguished by Necker under the name of berzeline, crystallizes in regular octahedrons, sometimes with truncated edges, and frequently in twins parallel to O. It is almost perfectly cleavable parallel to  $\infty O \infty$ ; pellucid, vitreous, of hardness over 5, and of 2.727 spec. grav. When rubbed, it exhibits phosphorescence, and before the blow-pipe it fuses with difficulty to a vesicular glass.

The zeagonite of Gismondi (considered by him to be identical with abrazite) from Capo di Bove, crystallizes in rhombic combinations of  $\infty \bar{P} \infty . \infty \bar{P} \infty . P$ ; the latter form yielding, according to Kengott's measurement,  $120^{\circ} 37'$  and  $121^{\circ} 41'$  over the polar edges, and  $89^{\circ} 13'$  over the middle edges. No cleavage; strong, vitreous lustre; spec. grav., in accordance with the observation of Marignac = 2.213.

In regard to the gismondine, Kengott agrees with Marignac, according to whom, the mineral crystallizes most probably in pyramids of the tetragonal system, measuring  $118^{\circ} 30'$  over the polar edges, and  $92^{\circ} 30'$  over the middle edges. It is, furthermore, imperfectly cleavable parallel to P, brittle, and of a pearly lustre. Hardness = 5; spec. grav. = 2.265. It intumescs before the blow-pipe, and fuses with tolerable ease to a vesicular enamel. It becomes phosphorescent during fusion.

**Carpholite.**—Kengott(2) has discovered, on the carpholite from Schlackenwalde, distinct crystals belonging to the rhombic system, and exhibiting combinations of  $\infty P . \infty \bar{P} \infty . \infty \bar{P} \infty$ , and n P. He found the angles of  $\infty P = 111^{\circ} 27'$  and  $68^{\circ} 33'$ .

**Prehnite (Jacksonite).**—J. D. Whitney, it will be remembered, described as a new species under the name of Jacksonite(3), a mineral

(1) Wien. Acad. Ber. October, 1850, 248—269.

(2) Ibid. 253.

(3) Annual Report for 1847 and 1848, II, 407.

possessing the composition of prehnite, but without the water of this latter. C. T. Jackson, however(1), has now found that it contains exactly the same amount as prehnite. In six experiments he obtained an amount of water varying between 4.15 and 4.7 per cent.

Kerl(2), at the suggestion of F. A. Römer, has analyzed an easily fusible mineral, much resembling wood-asbestos, which is found coating the sides of fissures in the Gabbro of the Radau valley, near Harzburg, often to the thickness of  $\frac{1}{8}$  of an inch :

| $SiO_3$ . | $Al_2O_3, Fe_2O_3$ . | $CaO$ . | $MgO$ . | Loss on ignition. | Total. |
|-----------|----------------------|---------|---------|-------------------|--------|
| 40.80     | 25.1                 | 27.8    | 2.9     | 30                | 99.6   |

Römer considers the mineral to be a kind of massive prehnite, possessing a prismatic or fibrous structure.

**Algerite.**—R. Crossley(3), at the request of Alger, and under the direction of Jackson, has examined Hunt's algerite(4). The crystals employed were of a honey-yellow colour; with hardness = 3—3.5; and spec. grav. = 2.78. They were very carefully freed from the adhering idocrase; and a complete decomposition was effected by treatment with a mixture of hydrochloric and sulphuric acid.—After abstraction of 4.21 per cent of mechanically-mixed carbonate of lime, the analysis, reckoned to 100 parts, gave the following numbers :

| $SiO_3$ . | $Al_2O_3$ . | $Fe_2O_3$ . | $MgO$ . | $KO$ . | $H_2O$ . | Total. |
|-----------|-------------|-------------|---------|--------|----------|--------|
| 52.00     | 25.42       | 1.54        | 5.39    | 10.38  | 5.27     | 100.00 |

Crossley deduces from the above, the formula  $3(MgO, KO), SiO_3 + 3(Al_2O_3, 2SiO_3) + 3H_2O$ .

**Vermiculite.**—C. T. Jackson(5) has given a more accurate description of the vermiculite from Milbury in Massachusetts (analyzed some years ago by Thomson), and R. Crossley has made a new analysis of the same. It is disseminated in a mealy substance (containing magnesia) in the form of dark olive-green, and apparently hexagonal leaves, which are readily separable and flexible, but not elastic. By transmitted light, these are transparent or translucent, and of an apple-green colour. Their hardness = 2, and their spec. grav. = 2.756. Heated in the bulb-tube, the vermiculite gives off water with an alkaline reaction, exfoliates and swells up, on the heat being continued, to about a hundred times its original volume—and with such force, as frequently to shatter the glass. It is decomposed both by hydrochloric and by sulphuric acid. The analysis gave :

(1) Sill. Am. J. [2] X, 121; Dana's Syst. of Mineral. 3rd edit. 313.

(2) Jahrb. Miner. 1850, 683.

(3) Sill. Am. J. [2] X, 77; Dana's Syst. of Mineral. 3rd edit. 680 (in abstr.); Phil. Mag. [3] XXXVII, 179.

(4) See Annual Report for 1849, III, 538.

(5) Sill. Am. J. [2] IX, 422; Dana's Syst. of Mineral. 3rd edit. 291 and 696.

| Vermicu-<br>lite. | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO.  | MgO.  | HO.   | Total. |
|-------------------|--------------------|----------------------------------|-------|-------|-------|--------|
|                   | 35·74              | 16·42                            | 10·02 | 27·44 | 10·30 | 99·92  |

Crossley deduces from his analysis the formula,  $4(3\text{RO}, \text{SiO}_3) + 2(\text{Al}_2\text{O}_3, \text{SiO}_3) + 9\text{HO}$ , and points out that this is Kobell's formula for pyrosclerite; and that, consequently, the vermiculite may be considered a variety of the latter. Kobell's analysis gave the oxygen-ratio of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 : \text{HO} = 6 : 3·51 : 8·68 : 4·19$ ; leading exactly to the formula,  $2(3\text{RO}, \text{SiO}_3) + \text{R}_2\text{O}_3, \text{SiO}_3 + 4\text{HO}$ .

**Katapleelite.**—P. H. Weibye(1) has bestowed the name of katapleelite (on account of its occurrence with several other rare substances) on a new mineral, from the coarse-grained syenite of Larmanskjaer, in the Island of Lamö. It occurs in, apparently, monoclinometric prisms of about  $120^\circ$ , with a terminating plane set upon the prismatic planes at the same angle as the above. The cleavage is perfect, parallel to the latter. Colour, light yellowish-brown; streak, Isabella yellow; opaque; dull, or with feeble lustre; hardness, about 6; spec. grav. 2·79 to 2·81. Easily fusible before the blow-pipe to a white enamel; becoming blue by treatment with cobalt-solution; and forming a colourless glass with borax. In the state of powder, it is readily decomposed, without gelatinization, by hydrochloric acid. Two analyses, performed by K. A. Sjögren, gave the following results:

|     | SiO <sub>3</sub> . | Zr <sub>2</sub> O <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | NaO.  | CaO. | FeO. | HO.  | Total. |
|-----|--------------------|----------------------------------|----------------------------------|-------|------|------|------|--------|
| I.  | 46·83              | 29·81                            | 0·45                             | 10·83 | 3·61 | 0·63 | 8·86 | 101·02 |
| II. | 46·52              | 29·33                            | 1·40                             | 10·06 | 4·66 | 0·49 | 9·05 | 101·51 |

Weibye calculates from the above, the formula  $3(\text{RO}, \text{SiO}_3) + 2\text{Zr}_2\text{O}_3, 3\text{SiO}_3 + 6\text{HO}$ .

**Melanolite.**—H. Wurtz(2) has described, under the name of melanolite, a mineral found by him at Cambridge in Massachusetts. It occurs as an incrustation on the sides of a fissure in syenite, and possesses a fibrous structure, but no cleavage. Soapy to the touch; lustre, resinous; colour, black; streak, dark olive-green; somewhat translucent in thin leaves. Hardness=2; spec. grav.=2·69. Fusibility, according to Kobell's scale, =2. Easily decomposed by hydrochloric acid, the silica separating in the state of powder. The analysis yielded:

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | FeO.  | NaO. | CaO, CO <sub>2</sub> . | HO.  | Total. |
|--------------------|----------------------------------|----------------------------------|-------|------|------------------------|------|--------|
| 30·86              | 3·92                             | 20·25                            | 21·97 | 1·62 | 12·77                  | 8·94 | 100·33 |

A second determination gave 30·93 per cent of silica, and 20·17 of sesquioxide of iron. [Two earlier analyses had been performed, but on impure specimens. We do not communicate the results of these.]

(1) Pogg. Ann. LXXIX, 300; Jahrb. Miner. 1851, 88 (in abstr.); Phil. Mag. [3] XXXVII, 235; Arch. Ph. Nat. XIV, 154; Sill. Am. J. [2] X, 245.

(2) Sill. Am. J. [2] X, 80; Dana's Syst. of Mineral. 3rd edit. 679 (in abstr.)

Throwing out the carbonate of lime, which the magnifying glass showed to be merely in admixture, Wurtz deduces from the given results the formula  $2 RO, SiO_3 + R_2O_3, SiO_3 + 3 HO$ .

**Aphrosiderite.**—Fr. Sandberger(1) has discovered a new mineral, belonging to the chlorite group, in the red-ironstone of the Giegenheit mine, near Weilburg. He has named this aphrosiderite. Under the magnifying glass, it exhibits an aggregation of extremely delicate, translucent, pearly scales, of a colour between olive and blackish-green. The streak is greenish-grey; hardness, 1; and spec. grav. 2·8. It becomes brownish-red when heated before the blowpipe, and fuses, but only on the thinnest edges, to a black mass. It is perfectly decomposed in the cold by hydrochloric acid. The following are the results of its analysis:

Aphrosiderite.

| $SiO_3$ . | $Al_2O_3$ . | MgO. | FeO.  | $H_2O$ . | Total. |
|-----------|-------------|------|-------|----------|--------|
| 26·45.    | 21·25       | 1·06 | 44·24 | 7·74     | 100·74 |

The oxygen-ratio of  $RO : R_2O_3 : SiO_3 : HO = 9·29 : 9 : 12·70 : 6·24$ , and leads to the formula  $3 (3 RO, SiO_3) + 3 R_2O_3, SiO_3 + 6 HO$ .

Sandberger is of opinion that all the so-called earthy chlorites of the red-ironstone beds belong to this mineral.

**Sericite.**—K. List has distinguished, under the name of sericite, a greenish- or yellowish-white talcose and saponaceous mineral. This substance, according to his view, forms, in combination with quartz, the principal portion of the Taunus slate. It is readily cleavable in curved and often contorted leaves, which are readily separable, and, in thin pieces, semi-transparent. Hardness = 1; spec. grav. = 2·897. Before the blowpipe, it gives off water, exfoliates, and melts with difficulty to a greyish enamel, emitting at the same time a brilliant light. The results placed under No. I, were obtained in an earlier analysis of the sericite of Naurod(2); those under No. II were furnished by a subsequent analysis, performed on a purer mineral(3).

|     | $SiO_3$ . | $Al_2O_3$ . | FeO. | MgO. | CaO. | KO.  | NaO. | $SiF_3$ . | $PO_5$ . | HO.  | Total. |
|-----|-----------|-------------|------|------|------|------|------|-----------|----------|------|--------|
| I.  | 51·83     | 22·21       | 7·50 | 1·38 | —    | 9·10 | 1·74 | —         | —        | 5·56 | 99·32  |
| II. | 50·59     | 23·64       | 8·21 | 1·11 | 0·62 | 9·10 | 1·74 | 1·88      | 0·31     | 3·44 | 100·64 |

List deduces from analysis No. II the formula  $2 (RO, 3 SiO_3) + 4 R_2O_3, 3 SiO_3 + 3 HO$ .

**Chloritoid.**—L. Smith(4) has met with chloritoid on the emery of the Gummuchdagh. It possesses a laminar structure, and is readily cleavable in the direction of the laminae. Colour, black; in

(1) Sandberger's Uebersicht d. Geolog. Verhältnisse von Nassau, 97; Jahrb. Minér. 1850, 341 (in abstr.)

(2) Jahrb. d. Ver. f. Naturk. im Herzogth. Nassau, 1850, 6. Heft, 131.

(3) F. Sandberger, Geogn. Skizze des Taunus in: Die Nassauischen Heilquellen beschrieben von einem Verein von Aerzten, Wiesbaden, 1851, 14.

(4) Ann. Min. [4] XVIII, 300.



Chlorite.  
toid.

thin leaves, transparent and dark green; shining on the cleavage-planes. Hardness=6; spec. grav.=3.52. Becomes brown before the blow-pipe, but does not fuse. Strong hydrochloric acid attacks it, but it is not completely decomposed except by sulphuric acid. The mean of three analyses gave the following results:

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO.  | MnO. | CaO. | MgO. | KO, NaO. | H <sub>2</sub> O. | Total. |
|--------------------|----------------------------------|-------|------|------|------|----------|-------------------|--------|
| 23.75              | 39.84                            | 27.62 | 0.52 | 0.64 | 0.58 | 0.30     | 6.85              | 100.10 |

The oxygen-ratio of  $RO : R_2O_3 : SiO_2 : H_2O = 1.08 : 3 : 2.03 : 0.98$ , corresponding exactly with the formula deduced by Smith,  $3 FeO, SiO_2 + 3 Al_2O_3, SiO_2 + 3 H_2O$ . [This is the original formula of Bonsdorff.]

**Silicates with Hydrates. Chrysotile.**—Delesse(1) has analyzed an exceedingly finely-fibrous chrysotile from the serpentine of the Vosges. Colour, light oil-green; talcose lustre; transparent; spec. grav.=2.23. Completely decomposed by sulphuric acid.

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO. | MgO.* | H <sub>2</sub> O. | Total. |
|--------------------|----------------------------------|------|-------|-------------------|--------|
| 41.53              | 0.12                             | 1.69 | 42.61 | 13.70             | 100.00 |

\* Determined from the loss.

**Marmolite, Deweylite, Williamsite, Slaty Serpentine, and Picrolite.**

—T. H. Garrett(2) has analyzed marmolite (I), from Hoboken, New Jersey; G. J. Brush(3), deweylite (II), and Shephard's Williamsite (III) (4, 5), from Texas, Lancaster County, Pennsylvania; B. Silliman, Jun.(6), the so-called slaty serpentine (IV), and also green picrolite (V), both from the same localities as Nos. II and III; and List(7) has analyzed the picrolite of Reichelstein, in Sillesia (VI).

|      | SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | FeO. | NiO.  | MgO.  | H <sub>2</sub> O. | Total. |
|------|--------------------|----------------------------------|----------------------------------|------|-------|-------|-------------------|--------|
| I.   | 42.32              | 0.66                             | —                                | 1.28 | —     | 42.23 | 13.80             | 100.29 |
| II.  | 42.60              | 3.13                             | —                                | —    | —     | 34.16 | 20.25             | 100.14 |
| III. | 45.02              | 3.35                             | —                                | —    | —     | 37.75 | 13.01             | 99.13  |
| IV.  | 44.58              | 3.03                             | —                                | 6.15 | trace | 34.51 | 12.38             | 100.65 |
| V.   | 44.25              | 4.90                             | —                                | 3.67 | 0.69  | 34.00 | 12.32             | 99.83  |
| VI.  | 44.60              | —                                | —                                | 2.63 | —     | 39.74 | 12.57             | 99.54  |

**Chlorite.**—L. Smith(8) has analyzed a foliated chlorite (I), occur-

(1) Ann. Min. [2] XVIII, 328.

(2) Dana's Syst. of Mineral. 3rd edit. 692.

(3) Ibid. 258.

(4) Ibid. 692.

(5) See Annual Report for 1847 and 1848; II, 42.

(6) Proceedings of the 2nd Meeting of the American Association, 134; Dana's Syst. of Mineral. 3rd edit. 692.

(7) Ann. Ch. Pharm. LXXIV, 241.

(8) Ann. Min. [4] XVIII, 304.

ring (often in the state of admixture with magnetite and emery), at the Gummuchdagh. Delesse(1), also, has analyzed a dark green chlorite (II), found in the form of small nodules in the serpentine of the Col de Pertuis, near Liesey in the Vosges. This latter, in the opinion of the analyst, consists of metamorphosed garnet; the nodules occasionally containing a kernel of that substance.

Chlorite.

|     | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | Ca <sub>2</sub> O <sub>3</sub> . | FeO.  | MnO. | CaO. | MgO.  | HO.   | Total. |
|-----|--------------------|----------------------------------|----------------------------------|----------------------------------|-------|------|------|-------|-------|--------|
| I.  | 27·20              | 18·62                            | —                                | —                                | 23·21 | —    | —    | 17·64 | 10·61 | 97·28  |
| II. | 33·23              | 14·78                            | 6·28                             | 1·49                             | —     | 1·39 | 1·86 | 30·76 | 10·21 | 100·00 |

Analysis No. I gives the oxygen-ratio of RO : R<sub>2</sub>O<sub>3</sub> : SiO<sub>3</sub> : HO = 4·18 : 3 : 4·97 : 3·24. If we make this = 12 : 9 : 15 : 9, we obtain the formula 4 (3 RO, SiO<sub>3</sub>) + 3 Al<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub> + 9 HO; from which it follows that this chlorite stands in close relationship to the chloritoid of the same locality (see p. 507).

**Leuchtenbergite.**—Breithaupt(2) considers that the leuchtenbergite is entitled to rank as a distinct and independent species, and that in the pure condition it is anhydrous.

**Silicates with Fluorides, Borates, and Titanates.**  
**Tourmaline.**—Rammelsberg(3) has communicated the results obtained by him, during several years, in the analysis of not less than thirty tourmalines from different localities. These analyses, conducted with the most extreme care, were principally undertaken with a view to determine the truth of the assertion—as concluded by Hermann from the analysis of several Siberian tourmalines and a whole series of epidotes(4)—that mineral groups exist, the members of which have a uniform crystallization, but differ from one another not merely in regard to the presence of different isomorphous bodies in their composition, but also in the possession of a dissimilar atomic constitution [Hermann's heteromero-isomorphism]. Rammelsberg has now found, in accordance with Hermann's views, that such is undoubtedly the case; but, on the other hand, he has shown that many tourmalines contain a small amount of phosphoric acid; and that fluorine also, in addition to boracic acid, is present in all. This newly discovered substance in the tourmaline, escapes in the form of terfluoride of silicon gas when the mineral is strongly heated; occasioning the well-known intumescence which Hermann, who did not detect fluorine

(1) Ann. Min. [4] XVIII, 304; Zeitschrift d. Deutschen. Geolog. Gesellsch. II, 432.

(2) Pogg. Ann. LXXX, 577.

(3) Pogg. Ann. LXXX, 449; LXXXI, 1; Berl. Acad. Ber. 1850, 273 (in abstr.); Zeitschrift d. Deutschen Geolog. Gesellsch. II, 241; J. Pr. Chem. LI, 177; Sill. Am. J. [2] XI, 257.

(4) See Annual Report for 1847 and 1848, II, 403.

Tourma-  
line.

in his analyses, attributed to the presence of carbonic acid. The following is a list of the tourmalines analyzed by Rammelsberg:

1. Brown tourmaline, from Gouverneur, St. Lawrence County, New Yqrk.
2. Brown tourmaline, from Windisch-Kappel, in Carinthia.
3. Colourless (or slightly-tinted pink or greenish) tourmaline, from Eibensteck in Saxony.
4. Brown tourmaline, from Oxford, New Hampshire.
5. Brown tourmaline, from Monroe, Connecticut, United States.
6. Black tourmaline, from the Zillethal.
7. Black tourmaline, from Godhaab in Greenland.
8. Black tourmaline, from Texas, Lancaster County, Pennsylvania.
9. Brownish-black tourmaline, from St. Gothard.
10. Black tourmaline, from Havredal, near Krageroe, in Norway.
11. Black tourmaline, from Ramfossen, near Snarum, in Norway.
12. Black tourmaline, from Haddam in Connecticut.
13. Black tourmaline, from the same locality.
14. Black tourmaline, from Unity, New Hampshire, United States.
15. Black tourmaline, from Bovey Tracy in Devonshire.
16. Black tourmaline, from Alabaskha in the Ural.
17. Black tourmaline, from Sonnenberg in the Hartz.
18. Black tourmaline, from the Herrschaft Saar in Moravia.
19. Black tourmaline, from Langenbielau in Silesia.
20. Black tourmaline, from Krummhou in Bohemia.
21. Bluish-black tourmaline, from Sarapulsk in the Ural.
22. Black tourmaline, from Elba.
23. Green tourmaline, from 'Elba.'
24. Green tourmaline, from Paris, Maine, United States.
25. Green tourmaline, from Brazil.
26. Green tourmaline, from Chesterfield, Massachusetts, United States.
27. Red tourmaline, from Elba.
28. Red tourmaline, from Paris, Maine, United States.
29. Red tourmaline, from Schaitansk in the Ural.
30. Red tourmaline, from Rozena in Moravia.

The specimens, in the state of a finely-levigated powder, were decomposed, partly by ignition with carbonated alkalis, or with carbonate of baryta, by means of a Plattner's blow-pipe apparatus, and partly by treatment with pure hydrofluoric acid. Rammelsberg found that a complete decomposition was effected by the latter method, after the minerals had been strongly heated in a wind-furnace. The loss which took place from this operation was reckoned in the calculations as terfluoride of silicon. For the determination of the amount of protoxide and sesquioxide of iron, Rammelsberg prefers the method of decomposition by fusion with glass of borax, first employed by Chenevix; and for the subsequent part of the operation, he made use of metallic copper or terchloride of gold. The boracic acid present in the mineral must, in almost all cases, be calculated from the loss, as, according to Rammelsberg's experience, we do not as yet possess a strictly accurate method for its direct determination. Rammelsberg subjected each of the tourmalines enumerated above, to several analyses, the mean of which is given in the following table:

| No. | Sp. gr. | Fl   | PO <sub>5</sub> | SiO <sub>3</sub> | BoO <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | Mn <sub>2</sub> O <sub>3</sub> | FeO  | MnO  | CaO  | MgO   | NaO  | KO   | LiO  | Total. | Tourmaline. |
|-----|---------|------|-----------------|------------------|------------------|--------------------------------|--------------------------------|--------------------------------|------|------|------|-------|------|------|------|--------|-------------|
| 1   | 3.049   | 2.28 | trace           | 38.85            | 8.25             | 31.82                          | 1.27                           | —                              | —    | —    | 1.60 | 14.89 | 1.28 | 0.26 | —    | 100.00 |             |
| 2   | 3.035   | 2.10 | 0.12            | 38.08            | 9.39             | 34.21                          | —                              | 1.43                           | —    | —    | 0.61 | 11.22 | 2.37 | 0.47 | —    | 100.00 |             |
| 3   | 3.034   | 2.51 | —               | 37.83            | 8.88             | 30.86                          | 4.85                           | —                              | —    | —    | 0.88 | 11.62 | 2.27 | 0.30 | —    | 100.00 |             |
| 4   | 3.068   | 2.50 | 0.24            | 38.33            | 8.86             | 33.15                          | 3.07                           | —                              | —    | —    | 0.77 | 10.89 | —    | 1.52 | —    | 100.45 |             |
| 5   | 3.068   | 2.38 | —               | 39.01            | 9.04             | 31.18                          | 3.44                           | —                              | 0.98 | —    | 1.81 | 9.90  | 1.82 | 0.44 | —    | 100.00 |             |
| 6   | 3.034   | 2.50 | 0.24            | 37.94            | 8.58             | 33.64                          | 2.79                           | —                              | 0.37 | —    | 0.98 | 10.46 | 2.13 | 0.37 | —    | 100.00 |             |
| 7   | 3.072   | 2.23 | 0.11            | 37.70            | 7.36             | 34.53                          | 4.63                           | —                              | 0.25 | —    | 1.25 | 9.51  | 2.00 | 0.43 | —    | 100.00 |             |
| 8   | 3.043   | 2.36 | 0.20            | 38.45            | 8.48             | 34.56                          | 3.31                           | 0.09                           | —    | —    | 0.71 | 9.11  | 2.00 | 0.73 | —    | 100.00 |             |
| 9   | 3.055   | 2.33 | 0.24            | 38.00            | 8.99             | 32.28                          | 6.36                           | —                              | 1.51 | —    | 1.31 | 7.27  | 1.43 | 0.28 | —    | 100.00 |             |
| 10  | 3.107   | 2.10 | 0.08            | 37.11            | 8.70             | 31.26                          | 7.57                           | —                              | 0.77 | —    | 0.80 | 9.43  | 1.78 | 0.32 | —    | 100.00 |             |
| 11  | 3.145   | 1.71 | 0.11            | 37.22            | 8.70             | 29.70                          | 11.45                          | —                              | 0.86 | —    | 0.65 | 7.94  | 1.13 | 0.53 | —    | 100.00 |             |
| 12  | 3.136   | 1.78 | trace           | 37.50            | 7.94             | 30.87                          | 8.31                           | —                              | 1.06 | —    | 1.61 | 8.60  | 1.60 | 0.73 | —    | 100.00 |             |
| 13  | 3.132   | 1.95 | —               | 36.55            | 4.87             | 32.46                          | 11.08                          | —                              | 0.50 | —    | 1.80 | 8.51  | —    | 2.28 | —    | 100.00 |             |
| 14  | 3.192   | 1.59 | —               | 36.29            | 6.94             | 30.44                          | 13.08                          | —                              | 2.08 | —    | 1.02 | 6.32  | —    | 1.94 | —    | 100.00 |             |
| 15  | 3.205   | 1.49 | 0.12            | 37.00            | 7.66             | 33.09                          | 9.33                           | —                              | 6.19 | —    | 0.50 | 2.68  | 1.39 | 0.65 | —    | 100.00 |             |
| 16  | 3.226   | 1.54 | —               | 35.74            | 8.00             | 34.40                          | 7.61                           | —                              | 8.60 | —    | 0.86 | 1.76  | 1.02 | 0.47 | —    | 100.00 |             |
| 17  | 3.243   | 1.64 | 0.12            | 36.51            | 7.62             | 32.92                          | 8.43                           | —                              | 9.51 | 0.11 | 0.72 | 0.78  | 1.36 | 0.58 | —    | 100.00 |             |
| 18  | 3.181   | 1.30 | trace           | 36.82            | 8.70             | 35.60                          | 6.57                           | —                              | 7.68 | —    | 0.81 | 1.55  | 0.98 | 0.09 | —    | 100.00 |             |
| 19  | 3.152   | 1.43 | trace           | 37.24            | 7.62             | 33.97                          | 10.77                          | —                              | 1.95 | —    | 0.62 | 3.65  | 1.93 | 0.82 | —    | 100.00 |             |
| 20  | 3.135   | 1.90 | —               | 38.43            | 8.06             | 34.25                          | 9.98                           | —                              | 1.44 | —    | 0.44 | 3.84  | 1.36 | 0.30 | —    | 100.00 |             |
| 21  | 3.162   | 1.75 | 0.06            | 38.30            | 6.32             | 36.17                          | 6.35                           | 3.71                           | 3.84 | —    | 0.27 | 0.53  | 2.37 | 0.33 | —    | 100.00 |             |
| 22  | 2.942   | 2.00 | —               | 36.71            | 7.11             | 36.00                          | 7.14                           | —                              | —    | 5.52 | 0.80 | 2.30  | 2.04 | 0.38 | —    | 100.00 |             |
| 23  | 3.112   | 2.35 | —               | 38.19            | 7.58             | 39.16                          | 3.14                           | —                              | —    | 4.26 | 0.84 | 1.00  | 2.40 | 0.34 | 0.74 | 100.00 |             |
| 24  | 3.069   | 2.00 | —               | 38.47            | 7.69             | 40.93                          | 3.08                           | —                              | —    | 1.55 | 0.80 | 1.21  | 2.36 | 0.36 | 1.47 | 100.00 |             |
| 25  | 3.107   | 2.09 | trace           | 38.55            | 7.20             | 38.40                          | 5.13                           | —                              | 2.00 | 0.73 | 1.14 | 0.73  | 2.37 | 0.37 | 1.20 | 100.00 |             |
| 26  | 3.108   | 2.10 | —               | 40.26            | 7.79             | 38.00                          | 2.91                           | 0.90                           | 3.80 | —    | 0.81 | 0.80  | 2.09 | 0.64 | 0.20 | 100.00 |             |
| 27  | 3.022   | 2.41 | 0.10            | 39.27            | 7.87             | 44.41                          | —                              | 0.64                           | —    | —    | —    | 0.78  | 2.00 | 30   | 1.22 | 100.00 |             |
| 28  | 3.019   | 2.58 | 0.27            | 38.33            | 9.00             | 43.15                          | —                              | 1.12                           | —    | —    | —    | 1.02  | 2.60 | 0.68 | 1.17 | 99.90  |             |
| 29  | 3.082   | 2.47 | 0.27            | 38.38            | 7.41             | 43.97                          | —                              | 2.60                           | —    | —    | 0.62 | 1.62  | 1.97 | 0.21 | 0.48 | 100.02 |             |
| 30  | 2.998   | 2.70 | 0.22            | 41.16            | 8.56             | 41.83                          | —                              | 0.97                           | —    | —    | —    | 0.61  | 1.37 | 0.41 | —    | 100.00 |             |

Allowing the boracic acid to replace a portion of the silica, and rejecting the fluorine and phosphoric acid, which are present in very immaterial quantity, Rammelsberg has calculated the oxygen-ratios of these tourmalines, and proposed the following subdivisions:

A. Brown and black tourmalines, not containing lithia:

- I. Magnesia-tourmalines, 3 RO, 2 SiO<sub>3</sub> + 2 (R<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub>)
- II. Magnesia-iron tourmalines, 3 RO, 2 SiO<sub>3</sub> + 4 (R<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub>)
- III. Iron-tourmalines, 3 RO, 2 SiO<sub>3</sub> + 6 (R<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub>)

B. Blue, green, red (and colourless), tourmalines, containing lithia:

- IV. Iron-manganese-tourmalines, RO, SiO<sub>3</sub> + 3 (R<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub>)
- V. Manganese-tourmalines, RO, SiO<sub>3</sub> + 4 (R<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub>)

The tourmalines No. 1 to 6 inclusive, belong to Group I. These are yellow and brown, and contain a small quantity of iron: but, on the other hand, the maximum of magnesia; their mean spec. grav. = 3.05. The tourmalines No. 7 to 14 inclusive, belong to Group II. They are of a black colour, and contain the medium amount of iron and magnesia: mean spec. grav. = 3.11. No. 15 to 20 belong to Group III, and comprise the blackest tourmalines, with the largest amount of iron, and the lowest amount of magnesia: mean spec. grav. = 3.19. Group IV includes the tourmalines No. 21 to 26. These are mostly of a green colour, and almost all contain lithia, accompanied, however, by iron and manganese: their mean spec. grav. = 3.083. Group V comprises the tourmalines No. 27 to 29—

Tourma-  
line. •

red specimens, containing lithia, but no iron: mean spec. grav. of 3.041. The composition of the tourmaline No. 30, which =  $\text{RO}, \text{SiO}_3 + 5 (\text{R}_2\text{O}_3, \text{SiO}_3)$ , does not allow it to be placed in any one of these five groups. The specimen analyzed, however, to judge from its external characters, and the fact of its containing disseminated scales of lithia-mica, was already in part decomposed; whilst all the other specimens appeared perfectly fresh. In this respect, indeed, they were selected with especial care. Rammelsberg believes that in its normal condition, the tourmaline in question possesses the formula  $\text{RO}, \text{SiO}_3 + 6 (\text{R}_2\text{O}_3, \text{SiO}_3)$ , and thus represents the third group of the second series, the analogue of Group III. He also points out that the tourmalines analyzed by him can only be brought to a uniform atomic constitution by adding the oxygen of the boracic acid to that of the bases  $\text{RO}$  and  $\text{R}_2\text{O}_3$ , when the oxygen-ratio of these to the silica becomes in every case as 4 : 3.

Rammelsberg considers, furthermore, that the isomorphous relationship of the five fundamental combinations discovered by him in the tourmaline, must necessarily be admitted—a conclusion with which their optical properties seem also to agree; and he conceives that the cause of this isomorphism must lie in the proportional relations of their atomic volumes, which in the groups IV, I, and V, II, III, are as 4 : 5 : 6 : 8. He is finally of opinion that similar relations between form and composition, occur likewise in the feldspars and micas (see page 497).

As the weathered tourmalines appear to be always interpenetrated or accompanied by mica, Rammelsberg considers—in accordance with the opinion of Blum and Bischof, by whom the peculiarity was first pointed out—that this substance may very possibly be a metamorphic product arising from tourmaline, feldspar, iolite, and many other minerals. He has sought, therefore, but without being able to obtain any definite result, to trace out the chemical stages of the phenomenon, by a comparative analysis of a black tourmaline (I) of 3.057 spec. grav. (locality unknown), with that of a white mica, of 2.831 spec. grav., imbedded in it; as well as by the analysis of the lepidolite (IV) which accompanied the tourmaline No. 30 of the preceding table.

|      | $\text{SiO}_3$ | $\text{Al}_2\text{O}_3$ | $\text{Fe}_2\text{O}_3$ | $\text{Mn}_2\text{O}_3$ | $\text{MgO}$ | $\text{CaO}$ | $\text{LiO}$ | $\text{KO}$ | $\text{NaO}$ | $\text{BoO}_3$ | $\text{Fl.}$ | $\text{HO}$ | Total. |
|------|----------------|-------------------------|-------------------------|-------------------------|--------------|--------------|--------------|-------------|--------------|----------------|--------------|-------------|--------|
| I.   | 36.70          | 35.35                   | 11.25                   | —                       | 4.56         | 0.75         | —            | —           | 11.09        | —              | —            | 0.30        | 100.0  |
| II.  | 48.78          | 32.36                   | 3.06                    | —                       | 1.28         | 0.29         | —            | 10.25       | 1.55         | —              | —            | 2.43        | 100.0  |
| III. | 41.16          | 41.83                   | —                       | 0.97                    | 0.61         | —            | 0.41         | 2.17        | 1.37         | 8.56           | 2.70         | 0.22*       | 100.0  |
| IV.  | 51.70          | 26.76                   | —                       | 1.29                    | 0.24         | 0.40         | 1.27         | 10.29       | 1.15         | —              | 7.12         | 0.16*       | 100.3  |

\* =  $\text{PO}_5$ .

No. III. is the previously-quoted analysis of the Rozena tourmaline (No. 30). It is reprinted here for comparison with No. IV.

**Danburite.**—G. J. Brush has met with danburite near Danbury in Connecticut, in perfectly-formed, pale yellow, vitreous and transparent crystals which occur up to an inch in size. According to Dana(1), these belong to the triclinometric system, and exhibit combinations of  $\infty \bar{P} \infty$ ,  $\infty \bar{P} \infty$ ,  $0P$ , and  $\bar{P} \infty$ , with the following inclinations:  $0P(P) : \infty \bar{P} \infty (M) = 110^\circ$  and  $70^\circ$ ;  $\infty \bar{P} \infty : \infty \bar{P} \infty (T) = 56^\circ$  and  $126^\circ$ ;  $0P : \infty \bar{P} \infty = 93^\circ$  nearly; and  $0P : \bar{P} \infty (e) = 135^\circ$ . (The position of these angles is not stated; but the preceding notation refers to the figure given by Dana, in which M represents the transverse or frontal plane, T the side plane, P the basal plane, and e a replacement of the upper right edge between P and T.) This extremely brittle mineral is distinctly cleavable parallel to  $0P$  and  $\infty \bar{P} \infty$ , and, less so, parallel to  $\infty \bar{P} \infty$ . Hardness = 7—7.5; spec. grav. = 2.95. Before the blow-pipe, it fuses easily, and tinges the flame siskin-green. Its analysis, performed by H. Erni, gave the following results:

|     | SiO <sub>3</sub> . | CaO.  | MgO. | NaO.            | KO.  | Fe <sub>2</sub> O <sub>3</sub> ,<br>Al <sub>2</sub> O <sub>3</sub> . | BoO <sub>3</sub> .* | Total. |
|-----|--------------------|-------|------|-----------------|------|----------------------------------------------------------------------|---------------------|--------|
| I.  | 49.74              | 22.80 | 1.98 | 9.82            | 4.31 | 2.11                                                                 | 9.24                | 100.00 |
| II. | 49.71              | 22.38 | 1.30 | not determined. |      | 1.65                                                                 | —                   | —      |

\* Determined from the loss.

Erni calculated from the above, the formula  $4(RO, SiO_3) + RO, BO_3$ .

**Schorlamite.**—Another analysis of the schorlamite has now been added to the list, by R. Crossley(2). Crossley's analysis agrees exactly with the results obtained by Whitney(3). It yielded:

| SiO <sub>3</sub> . | TiO <sub>2</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | Mn <sub>2</sub> O <sub>3</sub> . | CaO.  | MgO. | Total. |
|--------------------|--------------------|----------------------------------|----------------------------------|-------|------|--------|
| 26.36              | 21.56              | 22.00                            | trace                            | 30.72 | 1.25 | 101.89 |

**Niobates, Titanates and Tantalates. Æschynite.**—Hermann(4) has repeated his former analysis(5) of the æschynite. In this examination he separated the cerium and titanium as chlorides, and determined the state of oxydation of the latter, according to the method employed for the determination of the iron in tantalite (see p. 514.) He did not find any zirconia; but what he formerly took for that substance turned out to be a mixture of titanitic acid and oxide of cerium. The analysis gave:

| NbO <sub>2</sub> . | TiO <sub>2</sub> . | Ce <sub>2</sub> O <sub>3</sub> . | CeO. | LaO. | YO.  | FeO. | HO.  | Total. |
|--------------------|--------------------|----------------------------------|------|------|------|------|------|--------|
| 33.20              | 25.90              | 22.20                            | 5.12 | 6.22 | 1.28 | 5.45 | 1.20 | 100.57 |

From this Hermann calculates the formula  $2(CeO, LaO, TeO). (Nb_6O_{12}, TiO_2) + Ce_2O_3, 3(Nb_2O_5, TiO_2)$ .

(1) Sill. Am. J. [2] IX, 286; Dana's Syst. of Mineral. 3rd edit. 281.

(2) Dana's Syst. of Mineral. 3rd edit. 692.

(3) See Annual Report for 1849, III, 524.

(4) J. Pr. Chem. L, 193—197.

(5) J. Pr. Chem. XXXI, 89; XXXVIII, 116.

Pyro-  
chlore.

**Pyrochlore.**—Hermann(1) has also lately analyzed the pyrochlore from Miask, already examined by him at a former period(2); and in opposition to the analyses of Wöhler and Städelcr(3), he still finds no thoria in its composition. He now considers it possible, therefore, that it might have been accidentally mixed with the Brevig pyrochlore examined by Wöhler. It is known that the specimens from that locality occur in association with thorite. In any case, however, according to his opinion, neither thoria nor zirconia belongs to the mineral as a constant constituent.

| NbO <sub>2</sub> . | TiO <sub>2</sub> . | CeO, LaO. | YO.  | FeO* | CaO. | MgO. | K.   | Na.  | Fl.  | Total. |
|--------------------|--------------------|-----------|------|------|------|------|------|------|------|--------|
| 60.83              | 4.90               | 15.23     | 0.94 | 2.23 | 9.80 | 1.46 | 0.54 | 2.69 | 2.21 | 100.83 |

Hermann distinguishes in pyrochlore three separate species: microchlore, hydrochlore, and fluochlore. The first contains neither water nor fluorine; the second, water but no fluorine; and the third, fluorine but no water. To microchlore belongs the microchlore of Chesterfield in Massachusetts, and also the Frederiksvärn pyrochlore analyzed by Hayes. Hydrochlore comprises the pyrochlores from Frederiksvärn and Brevig, analyzed by Wöhler; and fluochlore, the specimens from Miask analyzed by Wöhler and by Hermann. All the pyrochlores, according to the latter chemist, consist essentially of a combination of equal equivalents of base and tantallike acid, which united in the proportion of 3:1 or 6:1 with a fluorine-compound of the formula RO, RFl, represent the fluochlores; and these compounds are capable of again crystallizing together. From the above analysis, Hermann deduces the formula  $RO, RFl + 3 [RO, (NbO_2, TiO_2)]$ .

**Tantalite and Columbite.**—As tantalite and columbite, according to the measurements of Nordenskiöld and Dana, possess crystalline forms not capable of being derived from one another, Hermann supposes(4), contrary to his earlier opinion(5), that their chemical constitution may also be dissimilar. He has consequently examined each species in regard to the amount of sesquioxide of iron present in its composition, by fusing the mineral with anhydrous borax, and boiling the resulting mass with metallic copper in hydrochloric acid, having previously satisfied himself that although titanio acid was reduced by this treatment, no reduction was effected by it on either tantalic acid, niobic acid, pelopio acid, nor ilmenic acid(6). In this manner, he found 4.42 per cent of sesquioxide of iron present in the columbite from Middletown in North America, but only 1.89 per cent in that from the Ilmen mountains; on which account, he considers that

(1) J. Pr. Chem. L, 185—192.

(2) J. Pr. Chem. XXXI, 94.

(3) See Annual Report for 1847 and 1848, II, 429.

(4) J. Pr. Chem. L, 164—172.

(5) See Annual Report for 1847 and 1848, II, 431.

(6) Ibid. I, 309.

the sesquioxide of iron in columbite is an inessential ingredient, and he does not, therefore, change the formula  $2\text{RO}, 3(\text{HfO}_2, \text{NbO}_2, \text{FeO}_2)$ . The tantalite from Kimito gave 8.34 per cent of sesquioxide of iron; and Hermann now calculates for this mineral, on the authority of Berzelius' analysis, the formula  $2\text{RO}, 3\text{TaO}_2 + \text{R}_2\text{O}_3, 3\text{TaO}_2$ .

Tantalum-ores.

**Tantalum-Ores.**—Hermann(1) has also published a systematic classification of the tantalum-ores.

**Samaraskite and Yttroilmenite.**—The samarskite, considered by H. Rose to be identical with yttroilmenite, has been now also analyzed by Hermann(2) and with almost the same results, so far as regards the metallic acids present in the same, as those obtained by Peretz(3). The specimen employed was opaque, and exhibited externally a greyish-brown coating of drusy crystals. Internally, it was black, with a shining, vitreous fracture. Hardness=5.5; spec. grav., as determined by Hermann,=5.64. The analysis gave

| $\text{NbO}_2$ * | $\text{FeO}$ | $\text{MnO}$ | $\text{UO}$ | $\text{YO}$ | $\text{CeO}, \text{LaO}$ | $\text{MgO}$ | Loss on ignition. | Total. |
|------------------|--------------|--------------|-------------|-------------|--------------------------|--------------|-------------------|--------|
| 56.36            | 8.87         | 1.20         | 16.63       | 13.29       | 2.85                     | 0.50         | 0.33              | 100.03 |

\* With a feeble amount of ilmenic acid

Hermann calculates from this the formula  $2\text{RO}, \text{NbO}_2$ , to which also the results obtained by Peretz lead, if these be referred to the atomic weight for niobic acid as determined by Hermann. Moreover, Hermann continues to assert that samarskite and yttroilmenite are totally distinct. Besides its dissimilar acid, he considers the latter mineral to be a neutral salt.

Mengite, polycrase, and probably also, polymignite—like wolfram, samarskite, and yttroilmenite—are, according to Hermann(4), homœomorphous with columbite. Hermann looks upon the three latter as heteromèrous compounds.

**Pyrrhite.**—J. E. Teschemacher(5) has discovered in albite from the Azores, small, transparent, orange-yellow octahedrons of the regular system, which he concluded to be pyrrhite. According to a qualitative examination performed by A. A. Hayes, the mineral consists essentially of niobate of zirconia, with the oxides of iron, manganese and uranium as subordinate ingredients.

**Tungstates. Wolfram.**—R. Schneider(6) has analyzed wolfram from the following localities:—I, from Zinnwald; II, from the Glasebach mine near Straßberg, in the Hartz; III, from the Pfaf-

(1) J. Pr. Chem. L, 197.

(2) J. Pr. Chem. L, 172—179

(3) See Annual Report for 1847 and 1848, II, 422

(4) J. Pr. Chem. L, 179—185

(5) Sil. Am. J. [2] IX, 423; Dana's Syst. of Mineral 3rd edit. 397 (in abstr.)

(6) J. Pr. Chem. XLIX, 321, Sil. Am. J. [2] X, 254, see Annual Report for 1847 and 1848, II, 434.



<sup>Wolfram.</sup> fenberg mine, near Neudorf, in the Hartz; and IV, from the Meiseberg mine, near the same place.

|       | WO <sub>3</sub> .* | FeO.  | MnO.  | CaO. | MgO.  | Total. |
|-------|--------------------|-------|-------|------|-------|--------|
| I.    | 76.01              | 9.81  | 13.90 | 1.19 | —     | 100.91 |
| II.   | 76.04              | 19.61 | 4.98  | 0.28 | trace | 100.92 |
| III.  | 76.21              | 18.54 | 5.23  | 0.40 | 0.36  | 100.74 |
| IV.†. | 76.25              | 20.27 | 3.96  | 0.28 | 0.15  | 100.91 |

W = 92.05, see page 206.

† Mean of three very closely agreeing analyses.

Schneider calculates from No. I, the formula 2 (FeO, WO<sub>3</sub>) + 3 (MnO, WO<sub>3</sub>); from No. II and III, 4 (FeO, WO<sub>3</sub>) + MnO, WO<sub>3</sub>; and from No. IV, 5 (FeO, WO<sub>3</sub>) + MnO, WO<sub>3</sub>. In order to decide the question respecting the state of oxydation of the tungsten in wolfram, Schneider fused the mineral with carbonate of soda in an atmosphere of carbonic acid. (The fusion was effected in a platinum crucible surrounded by carbonate of magnesia.) The fused mass was then treated with water, and this with hydrochloric acid, when nothing but tungstic acid was obtained. He also convinced himself that no sesquioxide of iron is to be met with in the solution obtained by treating wolfram with hydrochloric acid, in an atmosphere of carbonic acid at different temperatures; and that this holds good, whether the mineral be only partially or entirely decomposed.

Descloizeaux(1) has sought to prove that wolfram must be referred, not to the rhombic system, as stated by G. Rose and Kerndt, but to the monoclinometric, according to the original determination of Phillips. His measurements of crystals from Vilate, near Chanteloube (which, considered as monoclinometric, exhibited combinations of  $\infty P \cdot \infty P 2 \cdot \infty P \infty \cdot (P \infty) \cdot P \cdot -P$ ), gave for  $(P \infty) : \infty P \infty$ , over the front combination-edge,  $88^{\circ} 30'$ ; and  $91^{\circ} 10'$  to  $91^{\circ} 30'$  over the same edge at the back;  $P : \infty P \infty = 127^{\circ} 25'$  to  $127^{\circ} 45'$ ;  $-P : \infty P \infty = 128^{\circ} 5'$  to  $128^{\circ} 45'$ ;  $P : (P \infty) = 140^{\circ} 50'$  to  $141^{\circ} 25'$ ; and  $-P \cdot (P \infty) = 142^{\circ} 45'$ . He found the same angles in crystals from Altenberg and Zinnwald; and he calls attention, moreover, to the dissimilar conditions of the planes  $\frac{1}{2} P \infty$  and  $-\frac{1}{2} P \infty$  in the Zinnwald crystals; as well as to the fact, that in the twins united parallel to  $\infty P \infty$ , the dull roughened planes  $P \infty$  always form the re-entering, and the bright planes  $-P \infty$ , the salient angles. From the above and other measurements taken by him, Descloizeaux calculates the following inclinations:  $\infty P = 101^{\circ}$ ;  $P = 117^{\circ} 53' 48''$ ,  $119^{\circ} 37' 58''$ , all of these in the clinodiagonal principal section; and  $103^{\circ} 42' 56''$  in the orthodiagonal principal section;  $\alpha = 88^{\circ} 1' 8''$ . In the Altenberg and Zinnwald crystals he perceived the forms  $(\infty P 2)$  and  $(n P \infty)$ , the latter inclined to  $(P \infty)$  at an angle of  $163^{\circ} 20'$ , from which it follows that  $n=2$ , or strictly, 1.8.

(1) Ann. Ch. Phys. [3] XXVIII, 163; Arch. Ph. Nat. XIV, 59 (in abstr.)

**Scheelite.**—In hyacinth-red crystallized scheelite of 6·03 spec. grav., from the Hartz, Rammelsberg(1) found 78·64 per cent of tungstic acid, and 21·56 per cent of lime. Scheelite.

**Molybdates. Yellow Lead-Ore.**—C. Bergemann(2) has found 62·35 per cent of oxide of lead in bright yellow, nearly transparent crystals of the molybdate from La Blanca, in Zacatecas, Mexico. The mineral was quite pure(3).

**Vanadates. Dechenite.**—C. Bergemann(4) has also described, under the name of dechenite, a new vanadate of lead, discovered by Krantz, in a sandstone breccia with clay basis, near Niederschlettenbach, in the Lauterthale, in Rhenish Bavaria. It occurs in small crystalline botryoidal masses, of a yellowish-red colour, possessing a yellowish streak and resinous fracture. The more distinctly crystalline specimens are dark red, and strongly transiucent. Hardness = 3·5—4; spec. grav. = 5·81. No actual crystals have been found, but the larger specimens exhibit undeniable cleavage-lines, which appear to correspond with the faces of a rhombohedron. The mineral is readily fusible before the blow-pipe, and even in the bulb-tube, to a yellowish glass. It does not decrepitate; neither does it give off water in the tube, nor form a sublimate. On charcoal it yields lead globules, with the formation of a yellow ring of oxide of lead; and, occasionally, it emits an arsenical odour. With both borax and phosphorus-salt it forms a yellowish glass in the oxydating, and a green glass in the reducing flame. No phosphoric acid was found in pure specimens, either by the blow-pipe, or by liquid tests. The mineral is easily soluble in diluted nitric acid.—In the following analyses, the oxide of lead was precipitated by an excess of sulphuric acid, and digested in it a considerable time. The filtrate was evaporated, and the residue weighed after ignition. This was then again dissolved, and the remainder of the sulphuric acid separated from the vanadic acid by means of nitrate of baryta, and its amount deducted from the former weighing. A dark red specimen was employed for analysis No. I, and a yellowish specimen for No. II.

|     | PbO.   | VO <sub>3</sub> . | Total.  |
|-----|--------|-------------------|---------|
| Ia. | 52·915 | 47·164            | 100·079 |
| b.  | 53·717 | 46·101            | 99·818  |
| II. | 50·570 | 49·270            | 99·840  |

The mineral has consequently, the formula PbO, VO<sub>3</sub>.

**Aræoxene.**—Kobell(5) has given the name of aræoxene to a mineral which, in physical characters, resembles the red dechenite,

(1) Pogg. Ann. LXXVII, 245; Jahrb. Mineral. 1850, 346 (in abstr.)

(2) Pogg. Ann. LXXX, 400; Jahrb. Miner. 1851, 318 (in abstr.)

(3) See Annual Report for 1847 and 1848, II, 436.

(4) Pogg. Ann. LXXX, 393; Arch. Ph. Nat. XV, 248 (in abstr.); Phil. Mag. [4] I, 242.

(5) J. Pr. Chem. L, 496.

Aræoxene.

and which likewise contains vanadic acid and oxide of lead, but with the addition of oxide of zinc, a little arsenic acid, and a trace of phosphoric acid. It occurs at Dahn, in the Palatinate, sometimes accompanied by pyromorphite, in a sandstone fissure, in the form of botryoidal crystalline masses. These exhibit in the fracture traces of a radiated fibrous structure, and are translucent, moreover, and of a reddish or brownish-red colour, with pale yellow streak. Hardness=3. Easily fusible before the blow-pipe, with effervescence, yielding lead globules and an arsenical odour. With carbonate of soda on charcoal it yields also an infusible mass; which forms with borax a very pale yellowish-green glass in the oxydating, and a green glass in the reducing flame. A quantitative determination gave 48.7 per cent of oxide of lead and 16.32 per cent of oxide of zinc.

**Arsenates. Beudantite.**—J. Percy(1) has analyzed the Horhausen beudantite, the same specimen, in fact, from which Wollaston was supplied by Levy with the materials for his analysis. The crystals are considered to be cubes. They dissolve completely in dilute hydrochloric acid.

|     | PbO.  | Fe <sub>2</sub> O <sub>3</sub> . | SO <sub>3</sub> . | AsO <sub>5</sub> . | PO <sub>5</sub> . | HO.  | Total. |
|-----|-------|----------------------------------|-------------------|--------------------|-------------------|------|--------|
| I.  | 24.47 | 42.46                            | 12.31             | 9.68               | 1.46              | 8.49 | 98.87  |
| II. | 29.52 | 37.65                            | 12.35             | 13.60              | —                 | 8.49 | 101.61 |

Percy justly considers that what he analyzed was a mixture of sulphate of lead with arseniate of sesquioxide of iron; but H. J. Brooke(2) is opposed to the assertion that the latter consisted of pharmacosiderite mixed with sesquioxide of iron, as, according to Levy's authority, the beudantite crystallizes in rhombohedrons with replaced polar angles, the planes of R being bright, and those of O R dull; on which account it cannot be confounded with pharmacosiderite. Percy's analysis No. II, for which he picked out the crystals by the aid of a magnifying glass, gives the oxygen-ratio of Fe<sub>2</sub>O<sub>3</sub> : AsO<sub>5</sub> : HO = 11.9 : 5 : 7.6, from which the formula 4 Fe<sub>2</sub>O<sub>3</sub>, AsO<sub>5</sub> + 8 HO would follow.

**Mimetese.**—C. Bergemann(3) has analyzed arseniate of lead (mimetese), from the Azulaques mine near La Blanca in Zacatecas, Mexico. The analysis yielded in 100 parts: oxide of lead, 74.961; arsenic acid, 23.065; chlorine, 2.445; leading to the known formula 3 (3 PbO, AsO<sub>5</sub>) + PbCl. Not a trace of phosphoric acid was present.

**Carmine-spar.**—F. Sandberger(4) has distinguished by the name of carmine-spar, a new mineral which occurs in quartz at Horhausen in

(1) Phil. Mag. [3] XXVII, 161; Sill. Am. J. [2] XI, 231 (in abstr.)

(2) Phil. Mag. [3] XXXVII, 349.

(3) Pogg. Ann. LXXX, 401.

(4) Pogg. Ann. LXXX, 391; Arch. Ph. Nat. XV, 247 (in abstr.); Phil. Mag. [4] I, 242.

Nassau, accompanied by phaamacosiderite (beaudantite), minetese(1), pyrolusite, and brown-iron-ore. It forms tufts of translucent needles, and botryoidal and globular concretions of a radiated-fibrous structure; and is apparently cleavable parallel to the planes of a rhombic prism, with a pearly-vitreous lustre on the cleavage-planes. It is, farthermore, brittle; of a carmine-red, inclining to tile-red, colour; and is reddish-yellow in the streak. Hardness=2·5. On charcoal before the blow-pipe, it gives off arsenical fumes; yields lead globules with carbonate of soda, and produces an iron reaction with borax. It is readily soluble in hydrochloric acid. The solution has a golden-yellow colour, and contains all the iron in the state of sesquioxide. Arsenic acid is dissolved out of the mineral by caustic potassa. A quantitative analysis could not be made, owing to the insufficient amount of material.

Carmine-spar.

**Phosphates. Apatite (Francolite).**—The francolite of H. J. Brooke, from Wheal-Franco, near Tavistock, in Devonshire, is, according to an analysis by T. H. Henry(2), a variety of apatite, in which a part of the lime is replaced by the protoxides of iron and manganese. It occurs in mammillated masses, consisting of groups of small and very brilliant hexagonal prisms. The analysis, in which the phosphoric acid was determined by means of mercury, according to the method of H. Rose, gave the following results:

|     | CaO.  | FeO. | MnO. | PO <sub>5</sub> . | Fl.  | Total. |
|-----|-------|------|------|-------------------|------|--------|
| I.  | 53·38 | 2·96 |      | 41·34             | 2·32 | 100·00 |
| II. | 52·81 | 3·22 |      | 41·80             | 2·17 | 100·00 |

**Triphylline.**—C. Hartwell and E. Hitchcock have found a peculiar mineral, imbedded with spodumene in quartz, near Norwich in Massachusetts; and J. D. Dana and W. J. Crawford(3) have described the same. At first sight it resembles staurolite, for which indeed it was at first mistaken(4). It occurs in opaque, iron-black prisms, with scarcely any lustre, and with a brownish-red streak. These are met with up to 1½ inches in thickness. Hardness=5—5·5, spec. grav.=2·876. The system of crystallization to which the mineral belongs cannot, according to Dana's statement, be at present determined. Certain crystals, exhibiting combinations of  $\infty P$ .  $\infty \check{P} 2$ .  $\infty \check{P} \infty$ .  $0 P$ . and  $n \check{P} \infty$ , might be considered rhombic; but in many  $0 P$  appears to incline upon  $\infty \check{P} \infty$  at an oblique angle, whilst in others this is not the case. The planes  $\infty P$  also, it would seem, incline on each

(1) Verhandl. d. Naturh. Ver. f. d. Preuss. Rheinl. 1849, 60.

(2) Phil. Mag. [3] XXXVI, 134; J. Pr. Chem. L, 128 (in abstr.); Dana's Syst. of Mineral. 3rd edit. 681.

(3) Sil. Am. J. [2] X, 264; XI, 99, 100.

(4) Ibid. X, 121.

Triphyl-  
line.

side unequally on the planes  $\infty \bar{P} 2$ . The following measurements were obtained by means of the hand-goniometer;  $\infty P = 129^\circ 20'$ ,  $\infty \bar{P} 2 = 93^\circ$  (both in the brachydiagonal principal section); and  $OP : n \bar{P} \infty = 1:1^\circ$ . In other crystals, however, these angles differed from the above by several degrees. There is often a distinct cleavage parallel to  $OP$ , and an indistinct cleavage parallel to  $\infty P$ . The mineral intumesces before the blow-pipe, and fuses easily to a feebly-magnetic bead. Craw's analysis gave the following results, together with traces of alumina and magnesia:

|     | $PO_5$ . | $Mn_2O_3$ . | $Fe_2O_3$ . | $CaO$ . | $LiO$ . | $HO$ . | Insoluble residue. | Total. |
|-----|----------|-------------|-------------|---------|---------|--------|--------------------|--------|
| I.  | 41.35    | 24.70       | 27.36       | 1.97    | 2.27    | 2.07   | 0.29               | 100.01 |
| II. | 41.64    | 23.30       | 26.02       | 1.61    | 2.20    | 2.07   | 0.30               | 100.14 |

According to Craw, the mineral may perhaps be decomposed triphylline; but should its individuality be hereafter established by a more rigorous crystallographic investigation, its formula—in accordance with analysis No. II, which makes the oxygen-ratio of  $PO_5 : RO : R_2O_3 : HO = 15.15 : 1 : 9.06 : 1.12$ —may be considered  $= 3 RO, PO_5 + 3 (R_2O_3, PO_5, HO)$ , reminding one of that of alluadite(1). In adopting this formula, however, it must be assumed that the mineral analyzed had lost a portion of its phosphoric acid.

**Sulphates.** **Celestine.**—In a crystallographic examination of specimens of celestine from different localities, contained in the *Musée d'Histoire Naturelle* in Paris, Hugard(2) has remarked the following previously unobserved forms(3):  $\infty P$ ;  $\frac{1}{2} \bar{P} \infty$ ,  $2 \bar{P} \infty$ ;  $3 \bar{P} \infty$ ;  $\frac{1}{3} \bar{P} \infty$ ;  $2 P$ ;  $\bar{P} 2$ ;  $\bar{P} 4$ ; and  $\bar{P} 2$ .—His measurements show that the angles of celestine oscillate within certain limits; and he ascribes this, as the German mineralogists have long since done, to the presence of foreign bodies in admixture. He found  $104^\circ$ , as the mean of a great number of measurements, for the angle of the form  $\bar{P} \infty$  over a basal edge.

**Iron-Alum.**—B. Silliman, Jun.(4) has analyzed iron-alum from Oroomiah in Persia.

| $SO_3$ . | $Al_2O_3$ . | $Fe_2O_3$ . | $FeO$ . | $SiO_3$ . | $HO$ . | Total. |
|----------|-------------|-------------|---------|-----------|--------|--------|
| 33.812   | 10.617      | 1.050       | 9.150   | 3.340     | 41.611 | 99.580 |

**Nickel-Vitriol.**—T. S. Hunt(5) has discovered nickel-vitriol in the form of capillary needles, apparently belonging to the rhombic system,

(1) See Annual Report for 1847 and 1848, II, 439.

(2) Ann. Min. [4] XVIII, 3; Compt. Rend. XXX, 387 (in abstr.); XXXI, 469.

(3) Viewed according to the normal position assumed by Naumann, in which the cleavage prism is adopted for the form  $\bar{P} \infty$ . (Dufrenoy, Dana and others, it should be remembered, make this cleavage prism  $= \infty P$ ).

(4) Dana's Syst. of Mineral. 3rd edit. 226.

(5) Ibid. 679.

and also in the state of a greenish-white efflorescence, at the Wallace mine, Lake Huron. It contained no foreign admixtures.

Misy

**Misy.**—List(1) has analyzed the misy of the Alter Mann lode, in the Rammelsberg mine, near Goslar. It consisted of a loosely-aggregated mass of small, dark sulphur-yellow crystals, of a pearly or vitreo-pearly lustre. These appeared under the microscope to possess the form of rhombic tables, with the acute angles truncated; and they were held together by a small quantity of moisture which had an acid reaction, and contained free sulphuric acid. (This was got rid of, previous to the analysis, by washing with alcohol.) The misy was decomposed by water, with the separation of a reddish-yellow powder, and it dissolved easily and completely in hydrochloric acid. The analysis gave the annexed results

|    | Fe <sub>2</sub> O <sub>3</sub> . | ZnO   | MgO   | KO    | SO <sub>3</sub> | H <sub>2</sub> O | Total   |
|----|----------------------------------|-------|-------|-------|-----------------|------------------|---------|
| I  | 30 066                           | 2 491 | 2 812 | 0 318 | 42 922          | 21 391           | 100 000 |
| II | 30 365                           | —     | —     | —     | 43 308          | —                | —       |

After abstracting from this analysis oxide of zinc, potassa, and magnesia, together with the proper quantities of sulphuric acid and water for the formation of sulphates, List deduces the formula  $2 \text{Fe}_2\text{O}_3, 5 \text{SO}_3 + 6 \text{H}_2\text{O}$ . He also points out, in regard to this formula, that misy only differs from the copiapite in containing a smaller amount of water.

**Velvet Copper-Ore.**—J Percy(2) has analyzed, at Brooke's request, a specimen of velvet copper-ore, which he received from the latter(3). It dissolved easily in hydrochloric acid with the production of a slight effervescence, due to a small quantity of blue carbonate of copper in admixture, and with the deposition of a feeble residue. The analysis yielded.

|      | CuO.  | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | SO <sub>3</sub> | HO    | Insoluble residue | Total  |
|------|-------|--------------------------------|--------------------------------|-----------------|-------|-------------------|--------|
| I    | 48 16 | 11 70                          | 15 38                          | 23 06           | —     | —                 | 98 30  |
| II   | 46 59 | 11 06                          | 1 18                           | 14 12           | 23 06 | 2 35              | 98 36  |
| III. | 49 88 | 10 76                          | —                              | 16 75           | 22 61 | —                 | 100 00 |

Percy calculates from this, in equivalents,  $1 \text{Al}_2\text{O}_3, 6 \text{CuO}, 2 \text{SO}_3$ , and  $12 \text{HO}$ : values which indeed closely correspond with the oxygen-ratios deducible from each analysis.

Taking into consideration its crystalline condition, smalt-blue colour, and pearly lustre, the mineral might be viewed as a chemical combination of aluminite with a sulphate of copper containing just twice as much CuO as the brochantite. On this supposition its formula would be:  $6 \text{CuO}, \text{SO}_3, 3 \text{H}_2\text{O} + \text{Al}_2\text{O}_3, \text{SO}_3, 9 \text{HO}$ , which

(1) Ann Ch Pharm LXXIV, 239.

(2) Phil. Mag [3] XXVI, 100, Dana's Syst of Mineral 3rd edit 523

(3) Comp. Leonhard's Handb 2 Aufl 153, Mohs' Naturgesch des Min.-R. 2 Aufl. 657, Dufrenoy's Mineralogie, III, 153.

Carbon-  
ates.

agrees with the percentage composition given under analysis No. III.

**Carbonates.**—In regard to Sénarmont's production of carbonates with similar properties to those which occur in nature, see p. 174.

**Anhydrous Carbonate of Soda.**—W. Kayser(1) has analyzed a saline crust from the clay-slate of the New Margaret galena mine near Clausthal. This crust originated from the weathering of the slate (see the Report on Chemical Geology). Its analysis yielded :

| NaO, CO <sub>2</sub> . | FeO, CO <sub>2</sub> . | MgO, CO <sub>2</sub> . | CaO, CO <sub>2</sub> . | HO.  | Total. |
|------------------------|------------------------|------------------------|------------------------|------|--------|
| 92.07                  | 10.19                  | 3.32                   | 1.81                   | 1.85 | 99.24  |

It is, consequently, in all essential respects, an anhydrous carbonate of soda, a substance not previously observed as a mineral.

**Arragonite.**—E. Stieren(2) has analyzed arragonite from Papenberg near Hofgeismar

| CaO, CO <sub>2</sub> . | SrO, CO <sub>2</sub> . | HO.  | Total. |
|------------------------|------------------------|------|--------|
| 97.39                  | 2.22                   | 0.38 | 99.99  |

**Strontianite.**—Von der Marck(3) has analyzed the fibrous strontianite of Hamm. He found the spec. grav. = 3.613.

| SrO.  | CaO. | CO <sub>2</sub> . | SiO <sub>2</sub> and HO. | Total. |
|-------|------|-------------------|--------------------------|--------|
| 63.56 | 4.80 | 30.85             | trace                    | 99.21  |

The calcareous-spar which accompanied this strontianite, contained only 0.52 per cent of strontia.

**Dolomite (Bitter-Spar).**—H. Hirzel(4) has analyzed the following specimens of dolomite (bitter-spar) described by Breithaupt: I. From Traversella (*Carbonites eumetricus*, Br.), with the polar edges of R = 106° 20', and spec. grav. = 2.915—2.919; II. from Tinz near Gera (*Carbonites isometricus*, Br.), with the above angle = 106° 11', and spec. grav. 2.849—2.878; III. Lucullan, from Osterode in the Hartz :

|      | CaO, CO <sub>2</sub> . | MgO, CO <sub>2</sub> . | FeO, CO <sub>2</sub> . | MnO, CO <sub>2</sub> . | Total. |
|------|------------------------|------------------------|------------------------|------------------------|--------|
| I.   | 52.71                  | 33.46                  | 11.13                  | 2.84                   | 100.14 |
| II.  | 54.02                  | 45.28                  | 0.79                   | —                      | 100.09 |
| III. | 53.24                  | 46.84*                 | —                      | —                      | 100.08 |

\* With traces of manganese.

According to Hirzel's calculation, the equivalents of CaO, MgO, FeO, and MnO, in analysis No. I = 35 : 26 : 6 : 2. In No. II, and also in No. III, the CaO to the MgO and FeO = 1 : 1. The Traversella dolomite was named brossite, from the Brosso Valley.

(1) Jahrb. Miner. 1850, 682.

(2) Arch. Pharm. [2] LXII, 31.

(3) Ibid. LXIV, 175.

(4) Zeitschrift für Pharmacie, 1850, 24.

**Magnesite (Talc-Spar).**—R. Marchand and Th. Scheerer(1) have analyzed the yellow, transparent, and crystallized magnesite (I) from Lofthuus near Snarum, where it occurs in ancient gneiss; and also the white, opaque variety (II) from the same place. The first, according to Breithaupt(2), has a cleavage-angle of  $107^{\circ} 2' 85''$ , and a spec. grav. of 3.017. In Breithaupt's opinion, it is the purest variety of crystallized magnesite that is known.

Magnesite  
(Talc-spar)

|     | CO <sub>2</sub> . | MgO   | FeO. | SiO <sub>3</sub> . | HO.  | Total. |
|-----|-------------------|-------|------|--------------------|------|--------|
| I.  | 51.44             | 47.29 | 0.78 | traces             | 0.47 | 99.98  |
| II. | 51.44             | 46.90 | 1.41 | 0.25               |      | 100.00 |

The analyses were undertaken with a view to determine the equivalent of magnesia (see p. 204.)

R. Marchand and Th. Scheerer(3) have likewise examined the Frankenstein magnesite, and have found that the purest specimens contain, besides traces of phosphoric acid, only 0.009 per cent, and other specimens 0.048 per cent, of silica, alumina, and sesquioxide of iron as foreign admixtures.

**Ankerite.**—According to an analysis performed by Fridau(4), the ankerite of Admont, in Upper Styria, has the following composition:

| FeO.  | MnO. | CaO.  | MgO. | Gangue. | HO.  | CO <sub>2</sub> | Total. |
|-------|------|-------|------|---------|------|-----------------|--------|
| 21.57 | 1.32 | 26.70 | 6.54 | 1.47    | 0.15 | 11.95           | 99.70  |

**Siderose (Iron-Spar).**—According to Fr. Schmidt, Jun.(5), a massive and botryoidal siderose from St. Michael's mine, near Erlenlohe in the Fichtelgebirge, is composed as follows:

| CO <sub>2</sub> | FeO  | MnO. | CaO. | MgO | Total. |
|-----------------|------|------|------|-----|--------|
| 57.5            | 34.0 | 4.8  | 1.2  | 0.7 | 98.2   |

**Diallogite (Manganese-Spar).**—Gruner(6) has analyzed a strongly translucent, dark rose-red, and cleavable specimen of diallogite, possessing remarkably smooth planes, and with polar angle of about  $107^{\circ}$ ; spec. grav. = 3.57. The analysis yielded:

| MnO, CO <sub>2</sub> | FeO, CO <sub>2</sub> | CaO, CO <sub>2</sub> | MgO, CO <sub>2</sub> | Mn <sub>2</sub> O <sub>3</sub> . | Total. |
|----------------------|----------------------|----------------------|----------------------|----------------------------------|--------|
| 97.1                 | 0.7                  | 1.0                  | 0.8                  | 0.1                              | 99.7   |

This manganese-spar occurs near Vieille in the Pyrenees, underneath a layer of manganese-ore, in a fissure from  $\frac{1}{2}$  to  $\frac{4}{5}$  of an inch broad, passing through a schistose argillaceous limestone. As

(1) J. Pr. Chem. L, 395, 398; Pogg. Ann. LXXX, 313.

(2) Pogg. Ann. LXXX, 313, Sill. Am. J. [2] XI, 225 (in abstr.)

(3) J. Pr. Chem. L, 400.

(4) Hauding's Berichte über Mittheilungen von Freunden der Naturwissenschaften, V, 101.

(5) Fr. Schmidt d. j. die Gesteine der Centralgruppe des Fichtelgebirges, Leipzig, 1850, 13.

(6) Ann. Min. [4] XVIII, 61—69.



*Diallogite*  
(Manga-  
nese-spar)

there is no passage of the carbonate of manganese into the rock itself, and as no dendritic markings of manganese occur in this latter—so as to give rise to the inference that the substance in the fissure might be due to a process of solution. Gruner justly concludes that the mineral must have been deposited by an acid spring; and that the stratum of manganese-ore was formed by the farther oxydation of the greater part of the  $MnO$  by the action of the atmosphere. (See the Report on Chemical Geology.)

**Zinc-Spar.**—E. Schmidt(1) has analyzed zinc-spar from Moresnet:

| ZnO.  | $\frac{1}{2}Fe_2O_3$ . | CO <sub>2</sub> . | SiO <sub>2</sub> . | HO.  | Total. |
|-------|------------------------|-------------------|--------------------|------|--------|
| 63.06 | 0.34                   | 33.78             | 1.58               | 1.28 | 100.04 |

Respecting the formation of zinc-spar, see the Report on Chemical Geology.

**Cerussite.**—In an analysis of cerussite from the Friedrichssegen mine, near Oberlahnstein, R. Wildenstein(2) obtained 83.64 per cent of oxide of lead, and 16.36 of carbonic acid.

**Lancasterite.**—B. Silliman, Jun.(3) has distinguished by the name of lancasterite, a new mineral resembling brucite, from Texas, Lancaster County, in Pennsylvania. It occurs in white, translucent, and apparently monoclinometric, folia, which are somewhat flexible but not elastic, and which possess, on the perfect cleavage-planes, a strongly-marked, pearly lustre. Occasionally, also, it occurs in delicate needles and finely-fibrous masses. Hardness=2.5; spec. grav.=2.33—2.35. Two analyses performed by H. Erni, gave the following results:

|     | CO <sub>2</sub> . | MgO.  | FeO. | HO.   | Total. |
|-----|-------------------|-------|------|-------|--------|
| I.  | 27.07             | 50.01 | 1.01 | 21.60 | 99.69  |
| II. | 26.85             | 50.72 | 0.96 | 21.47 | 100.00 |

According to these analyses, the formula= $MgO$ ,  $CO_2 + MgO$ , 2 HO.

**Borates. Boracite.**—R. Weber(4) has analyzed opaque and somewhat weathered boracite from Lüneburg:

|     | MgO.  | $Fe_2O_3$ . | BoO <sub>3</sub> .* | Total. |
|-----|-------|-------------|---------------------|--------|
| I.  | 32.23 | 0.79        | 66.98               | 100.00 |
| II. | 32.86 | 0.45        | 66.69               | 100.00 |

\* Determined from the loss.

**Chlorides. Corneous Lead.**—Krug von Nidda(5) has discovered

(1) J. Pr. Chem. LI, 257.

(2) Jahrb. d. Ver. f. Naturk. im Herzogth. Nassau, 6 Heft, 200.

(3) Sill. Am. J. [2] IX, IX, 216; Dana's Syst. of Mineral. 3rd edit. 313, 686 (in abstr.)

(4) Pogg. Ann. LXXX, 282.

(5) Zeitschrift d. Deutschen Geolog. Gesellsch. II, 128; Jahrb. Miner. 1851, 200 (in abstr.)

the rare corneous lead (phosgenite) in several of the zinc-mines of Upper Silesia, more especially in the Elizabeth mine. The specimens are perfectly and equally cleavable in three directions at right angles to one another. They are also semi-transparent, and exhibit a smoke-grey colour and conchoidal fracture. Hardness = 2·5. Lustre, partly vitreous, partly resinous. An analysis gave 50·45 per cent of chloride of lead, 49·44 of carbonate of lead, and 0·003 of silver.

Corneous  
lead.

**Percylite.**—H. J. Brooke(1) has distinguished by the name of percylyte, a mineral which he received from Heuland; and which was stated to have come from La Sonora, in Mexico. It is crystallized in small sky-blue cubes. According to an examination by J. Percy, these become emerald-green when gently heated. At a stronger heat the mineral decrepitates, gives off water, and fuses to a brown liquid, which solidifies on cooling to a brown fissured mass. A sufficient quantity for a complete analysis could not be extracted from the matrix—which consisted of quartz and red oxide of iron, and contained gold—but a small portion was dissolved out by means of dilute nitric acid. This yielded 2·66 of lead, 0·77 of copper, and 0·84 of chlorine; according to which, the composition of the mineral might be represented by the formula  $Pb_2Cl + Cu_2Cl + HO$ . Percy, however, considers it to be an oxy-chloride, and that its composition corresponds to the formula  $PbCl, PbO + CuCl, CuO + HO$ .

**Pseudomorphs.**—Haidinger(2) has described a pseudomorph of brown-ironstone imitative of gypsum, discovered by Tunner in the old mines of Zeyring, near Judenburg in Upper Styria. He has also(3) described pseudomorphs, which he received from Liebenor, of serpentine and steatite imitative of the pyrgom variety of augite. These consist of very large crystals, composed of a number of smaller ones, in part unchanged, set in a paste of serpentine or steatite. They occur in the Fassathal.—V. Zepharowich(4) has described a pseudomorph of cerusite after galena, from Beresowsk.

Krug von Nidda(5) has discovered in several of the zinc-mines of Upper Styria, notably in the Elizabeth and Severin Mine, pseudomorphs of cerusite after corneous lead (phosgenite). These are of an ochre-yellow colour, and occur up to 3 inches in length, and  $\frac{3}{4}$  of an inch in breadth. They present, as predominating forms, the planes of the first and second prism, or those of an acute pyramid; and as

(1) Phil. Mag. [3] XXXVI, 131; J. Pr. Chem. XLIX, 512 (in abstr.); Dana's Syst. of Mineral. 3rd edit. 497.

(2) Haidinger's Berichte über d. Mittheilungen von Freunden d. Naturwissenschaften, V, 85.

(3) Ibid. VI, 77.

(4) Ibid. 121; Jahrb. Miner. 1851, 92 (in abstr.)

(5) Zeitschrift d. Deutschen Geolog. Gesellsch. II, 126; Jahrb. Miner. 1851, 200 (in abstr.)

Pseudo-  
morphs.

subordinate forms, the end planes, 0 P, with several obtuse pyramids, and a ditetragonal prism. Frequently they contain a kernel of phosgenite. They lie irregularly, or in stellated groups, in a barren marly clay; sometimes in such quantities as to render it worth working. Krug attributes the formation of this pseudomorph, to the decomposition of the corneous lead by the action of carbonate of lime in the mine waters.

**Organoïds. Copalline.**—Kengott(1) has recognized the identity of a mineral resin, distinguished as “fossil copal from the East Indies,” with the copalline of Highgate Hill near London. The substance examined was of a light honey-yellow colour, and perfectly transparent. It possessed also a vitreo-waxy lustre and conchoidal fracture. Its hardness was a little over 2, and its spec. grav.=1.053. It melted at a moderate heat, caught fire readily, and burnt with a very smoky flame, and without leaving any ash. Boiling alcohol dissolved but a small quantity of it. Insects and algoid plants were inclosed in the substance of the resin. An analysis performed by Duflos yielded:

| C.    | H.    | O.   | Total. |
|-------|-------|------|--------|
| 85.73 | 11.50 | 2.77 | 100.00 |

**Pyropissite.**—Kengott(2) has also distinguished by the name of pyropissite a carbonaceous substance—previously considered to be earthy brown-coal, and employed as such—which constitutes layers of from  $\frac{1}{2}$  to  $\frac{3}{8}$  of a fathom in thickness in the brown-coal of Weissenfels near Halle. It is opaque, dull greyish-brown, easily frangible, and with earthy fracture. By rubbing with the finger-nail it takes a resinous polish. Spec. grav.=0.493 to 0.522. Boiling alcohol extracts 30 per cent of a white, easily fusible, and inflammable substance, resembling wax. A very slight quantity is dissolved out by oil of turpentin or caustic potassa. Heated above 100° C., the pyropissite fuses with great bubbling, and with the emission of copious white fumes, to a black mass resembling asphalt, and of 1.145 spec. grav. This is only slightly attacked by alcohol, but the greater part dissolves in oil of turpentin. It burns with a very sooty flame. According to the experiments of R. F. Marchand(3), the pyropissite yields as much as 62 per cent of paraffine, and 1 lb. of it gives 3 cubic feet of ordinary gas.

Respecting anthracite and non-bituminous coal, consult p. 469.

**Dopplerite.**—According to a communication from Tschudi(4), Dörig has discovered the dopplerite(5) in peat-beds near the Gonten Bath, not far from the village of Appenzell.

(1) Kengott's Mineral. Untersuchungen, 2 Heft, 81 and 153.

(2) Ibid. 87.

(3) Intelligenzblatt zur Allgem. Hall. Lit. Zeit. June, 1849, 188.

(4) Wien. Acad. Ber. March, 1850, 274.

(5) See Annual Report for 1849, III, 552.

# CHEMICAL GEOLOGY.

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**General Matters. Magnetism of Rocks.**—A. Delessé(1) has examined, in regard to their magnetic power, the glasses obtained by the fusion of various granitic, porphyritic and volcanic rocks, according to his original method, given in the Report for 1849, p. 115. For the results obtained, we must refer the reader to the paper itself.

General  
matters.  
Magnet-  
ism of  
rocks.

**Action of Magnetism on the Crystallization of Rock Constituents.**—It has been remarked that in the strongly magnetic rocks, such as serpentine, malaphyre, basalt, &c., the minerals which form the basis, and those which have been subsequently elaborated in this basis, are quite different from those which occur in the veins and amygdaloidal cavities—the former containing iron, and the latter very little, or none, of that metal. Delessé(2) believes that the cause of this, lies in the action of magnetic and diamagnetic powers developed during the separation and crystallization of the different minerals; and he is of opinion, that the minerals belonging to the basis of these rocks, as well as part of those eliminated from the rock, have been produced, at an after period, in the wet way. The most magnetic substances, exercising an attractive action on the basis, were retained in it, and formed into the minerals containing the largest amount of iron; whilst the diamagnetic substances were driven by a repellant action into the hollows and fissures, and there aggregated into the minerals of the amygdaloidal cavities and veins.

Respecting the application of this hypothesis to the geological history of the serpentine of the Vosges, and to that of the melaphyre of Oberstein—and also for the apparent exceptions to the rule—we must refer to the original paper.

**Influence of Pressure on the Nature of Eruptive Rocks.**—Bunsen's investigations(3) "On the influence of pressure on the fusion-point of

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(1) Compt. Rend. XXX, 84; Instit. 1850, 33.

(2) Bull. Géol. [2] VIII, 108; Compt. Rend. XXXI, 805 (in abstr.); Instit. 1850, 411; Arch. Ph. Nat. XVI, 64.

(3) Loc. cit. 33; likewise Jahrb. Miner. 1851, 220; Instit. 1851, 180.

Influence  
of pressure  
on the  
nature of  
eruptive  
rocks.

bodies," have shed a new light on the cause of the great variety of eruptive rocks, both plutonic as well as volcanic; and have conducted to an explanation of the anomaly which has hitherto existed respecting the order in which the crystallization of the separate constituents has taken place, when compared to their degrees of fusibility(1). These researches show also the great importance to be derived from the analysis of the entire mass of rock-compounds, considered as a whole—a method of procedure hitherto much neglected. An examination of the characteristic rocks of Iceland has led Bunsen to the result, that these rocks, and probably also those of the Armenian volcanoes, may be derived from eruptions, either single or combined, from only two independent sources. The first has furnished the trachytic, and the second the augitic rocks; but from the union of these two an intermediate group also arises, to which Bunsen gives the denomination of tracheo-pyroxenic rocks. Both the trachytic and the augitic series invariably exhibit—unless in some few exceptional cases, evidently occasioned by local circumstances—a constant *average composition*, however much they may otherwise differ in regard to position, age, and lithological or mineralogical nature. This consists in the oxygen of the silica being to that of the bases, in the trachytic rocks, as 3 : 0.58; and in the augitic rocks, as 3 : 2. Between these extremes lie the tracheo-pyroxenic rocks, the composition of which may be calculated beforehand, if only the percentage amount of one of the constituents be known. The amount of the silica answers best for this purpose.—Silica-combinations, having the same constituents present, in the same proportions, by solidification under different pressures, are capable of producing rocks which, mineralogically, are quite distinct from one another. Under a pressure which, in the case of eruptive rocks, must amount to many thousand atmospheres, the solidification-point of the constituents of these rocks must vary within several hundred degrees. Feldspar, mica, hornblende, augite, olivine, and many other substances, which, under a given pressure, solidify at particular temperatures, must crystallize out, under other pressures, at totally different degrees; and if, in different bodies, as Bunsen's researches indicate, the variation of the melting-point differs for equal differences of pressure, the order of the separation of these bodies, under particular conditions—and through this, their chemical constitution—must also be affected. This circumstance must exercise a far greater influence on the formation of these rocks than that effected by the manner of their cooling.

**Theory of Geysers.**—J. Müller(2), in support of Bunsen's geyser

(1) See Annual Report for 1847 and 1848, II, 456.

(2) Pogg. Ann. LXXIX, 350.

theory(1), has constructed an apparatus, by means of which the geyser action is produced in miniature.

Emanation products of Vesuvius.

**Emanation-Products of Vesuvius.**—A. Scacchi(2) has devoted his especial attention to the phenomena connected with Vesuvius, during the years 1840 to 1850; and more particularly to the volcanic products brought to light by the fumeroles and solfataras of Puzzuoli, subsequent to the eruption in February of the latter year. Scacchi opposes the theory of craters of elevation, and holds, therefore, that the Somma itself is entirely formed of erupted matter(3). The thunderings which accompanied the ascending vapours in the interior of the crater, he considers to be due to electrical discharges in the upper part of the crater-cavity.—Amongst the more interesting minerals produced during these years may be enumerated the chloride of lead or cotunnite, which occurred in 1840 near the Punta del Mauro, although likewise previously known; and also the sulphate of potassa (apthalose), which was present in great quantity in the lava current of November, 1848. The eruption of 1845 yielded numerous brilliant crystals of augite and leucite, and these have been reproduced on later occasions. Crystals of sulphur were not once found during the entire period mentioned above, although sulphurous acid was abundantly exhaled. In 1839 and 1840, however, a very small quantity of sulphur occurred at the bottom of the crater.

In the year 1850, gypsum was one of the most important substances derived from the gaseous exhalations. It was both in the form of tufts of crystalline needles frequently coloured with sesquichloride of iron, and in that of an abundant crust, from  $\frac{1}{4}$  to  $\frac{1}{2}$  of an inch in thickness, coating the sand and scoræ; but it did not arise from these latter by weathering, as the cinders thus covered were in other respects quite unaltered. The two following hypotheses have been proposed to account for the formation of this substance. Scacchi gives the preference to the second view. The first supposes that the gypsum, in solution in water, was carried up with the steam derived from this latter; whilst the second assumes that chloride of calcium was given off in the gaseous condition—or, better still, in solution in the aqueous vapours—and that this was subsequently decomposed by sulphurous acid and steam.—Treated with distilled water, the gypsum exhibits an admixture of a large quantity of hydrochloric acid, sulphuric acid, alumina, potassa, and sesquioxide of iron, together with a small quantity of protoxide of iron. This eruption also produced two other substances, each of which consists of a mixture of various compounds. The one is of a white

(1) Annual Report for 1847 and 1848, II, 478.

(2) Ann. Min. [4] XVII, 323; Arch. Ph. Nat. XV, 251 (in abstr.)

(3) See L. von Buch's objections to this in the Zeitschrift d. Deutschen Geolog. Gesellsch. I, 107.

Emanation-products of Vesuvius.

colour (or, here and there in patches, yellow), very soft, and in the form of mushroom-like concretions which possess a bitter taste, and are very soluble. This substance contains sulphuric acid, hydrochloric acid, alumina, potassa, magnesia, and both protoxide and sesquioxide of iron. Treated with water, a great quantity of alum crystals, and a few of sulphate of soda, are deposited, and afterwards, large crystals of sulphate of magnesia. In the mother-liquid, alumina and protoxide of iron were found, together with a little sesquioxide of iron, magnesia, and soda, in combination with sulphuric and hydrochloric acid. On one or two of the fumaroles, some crystals of pure sulphate of soda were met with. The second substance forms earthy stalactites of a dark-red colour, and is  $\frac{1}{10}$  soluble in water. In the solution, alumina, lime, magnesia, sulphuric acid, and a little chlorine, were observed. It dissolved completely in hydrochloric acid. The analysis of 1.406 gr. yielded: .

| SO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO.  | MgO.  | KF.   | Loss.<br>(chlorine) | Total. |
|-------------------|----------------------------------|----------------------------------|-------|-------|-------|---------------------|--------|
| 0.348             | 0.283                            | 0.505                            | 0.050 | 0.050 | 0.033 | 0.121               | 1.406  |

On this occasion, furthermore, chloride of potassium and chloride of sodium occurred for the first time at Vesuvius. These bodies were combined in the proportion of KCl 37.55 to NaCl 62.45. Sulphur also occurred in small crystals and in fused globules, and iron glance in microscopic scales; but neither the chloride nor the suboxide of copper were present. Finally, an extremely minute quantity of sal-ammoniac was developed, and that only where the lava reached the cultivated zone. It is Scacchi's opinion, indeed, that this substance always originates from organic bodies—an assumption, however, which does not harmonize with its constant occurrence on the solfatare of Puzzuoli. The Vesuvius crystals were principally rhombic dodecahedrons or cubes, and combinations of the two; but many hemitropic combinations also occurred.

An abundance of hydrochloric acid, with carbonic acid, was present in the mofettas.

The lavas, consisting of leucitic or augitic porphyry, contained much augite and leucite, especially the former, also, a little mica.

The ashes consisted of two parts: a very fine dust, and small granular masses. The last, which could be separated from the dust by washing, were composed of augite and leucite, with mica scales and titanite iron. Water extracted from these ashes a thousandth part, consisting of gypsum and the other salts found in the crater.

**Formation of Manganese-Deposits.**—The manganese-ore of the environs of Vielle and Germ, on the eastern slope of the Pyrenees, lies in large beds and layers in a calcareous clay-slate belonging to the Devonian epoch. Gruner(1) attributes the formation of this ore,

(1) Ann. Min. [4] XVIII, 61.

which invariably occurs over lines of dislocation in a zone parallel to the main axis of the chain (N. 18° W.) to the action of springs containing bicarbonate of manganese in solution. The imbedded masses of the ore terminate below in fissures lined with the crystallized carbonate. These represent the outlet channels of the springs. The ore itself is mostly earthy, rarely vitreous or crystalline, and consists of a variable mixture of sesquioxide and peroxide of manganese with carbonate of the oxide. It has evidently been derived entirely from this latter. The rock which encloses it remains unaltered, except where the ore is in contact with limestone. The latter is then somewhat corroded, or formed into a limestone-breccia with manganese-cement.

Formation  
of manga-  
nese  
deposits

Gruner gives a similar origin—that of deposition from carbonated springs—to other manganese-deposits in France (Thiviers and Nonion), where manganite occurs in the clays of the Lower Oolite, with non-shot jasper, hornstone-nodules, halloysite, red oxide of iron, and heavy spar—the latter sometimes forming the substance of fossil shells. Under this formation lies the Jurassic dolomite, passing gradually lower down into limestone containing more or less carbonate of iron and manganese, and traversed by veins of heavy spar. Then follows the slate-series, with numerous veins of heavy spar, blende, galena, and pyrites, containing the same hornstone-nodules. These veins formed, as before, the outlet channels of the springs. The baryta was probably held in solution in the latter, in the form of sulphide of barium, like the sulphide of sodium contained at the present day in certain springs in the Pyrenees. It might also have been present in the state of carbonate of baryta, and have been afterwards converted into the sulphate by springs containing sulphuretted hydrogen. The zinc and lead were deposited from bicarbonates, and not produced by the oxydation of sulphur compounds, for only the most trifling amount of gypsum is present in the limestone. The blende, galena and pyrites were formed by springs which contained sulphuretted hydrogen or alkaline sulphides.

The formation of the slate by the agency of acid springs producing a kaolin-cement, was the first stage in this series of changes. Then came siliceous springs, hardening the slate; and finally, springs which deposited sesquioxide of iron and baryta.

In the second period, during the formation of the Liass-marl, the springs were more especially calcareous, but they contained also iron and manganese.

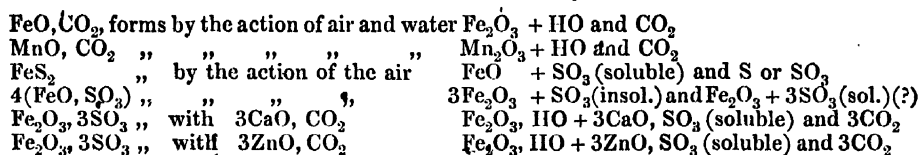
In the third period, that of the Lower Oolite, the springs possessed the greatest energy (deposition of the *terrain à jaspes*). They held in solution—silica, carbonic acid, and the bicarbonates of iron and manganese, with, more rarely, those of baryta, lead and zinc. Here and there also, they contained hydrofluosilic acid giving rise to the production of fluor-spar.—At a later interval appeared the sulphur-springs



Formation  
of  
calamine  
beds.

which effected the transformation of the carbonates into sulphides.—Each of these periods commenced with well-marked movements of depression, and various lines of dislocation took place during their continuance.

**Formation of Calamine Beds.**—Delanoue, Krug von Nidda, and Monheim have studied the phenomena connected with the mode of formation of calamine beds.—Delanoue(1) considers these ores to be deposits from thermal springs. They occur in irregular cavities in rocks of different ages, but are always situated over lines of fracture. The different ores are commonly mixed together in such a manner, as to indicate a simultaneous deposition. Frequently, however, they may be separated into the following series, passing from the newest to the oldest: 1. calcspar; 2. manganite; 3. hydrated sesquioxide of iron (hydrosiderite) holding more or less zinc; 4. zinc-bloom (zinconite, hydrous carbonate); 5. carbonate of zinc, carbonate of manganese; 6. carbonate of zinc, carbonate of manganese, carbonate of iron; 7. carbonate of zinc—the most abundant ore; 8. carbonate of lead, pyromorphite; 9. hydrous silicate of zinc; 10. willemitite; 11. pyrites; 12. blende containing cadmium; 13. argentiferous galena. Since the commencement, many epigenic compounds have been formed, and are still forming. The most important are:



It thus appears, that the opinion which ascribes the origin of sulphate of zinc to the decomposition of blende is incorrect. The sulphides, on the contrary, have themselves originated from the reduction of sulphates, by the organic matters of the limestone, or of the springs. That the springs which gave rise to these formations, were thermal, is concluded by Delanoue from the fact, that chloride of zinc was not precipitated in the least by limestone and Altenberg dolomite at the common temperature, but perfectly from warm solutions. Chloride of lead was thrown down in a similar manner, only more quickly, and the reaction took place in the cold. The same applies to chloride of manganese; and a solution of cobaltic manganese-ore yielded a precipitate containing cobalt. The presence of sulphur and pyrites proves, however, that the temperature of the springs was not very high, as the latter mineral would otherwise have been changed into  $\text{FeS}$  or  $\text{Fe}_7\text{S}_8$  (magnetic pyrites), and the sulphur,

(1) Ann. Min. [4] XVIII, 455; Compt. Rend. XXX, 765 (in abstr.); Arch. Ph. Nat. XV, 71; Instit. 1850, 194.

thus set free, would have been sublimed. The silicate of zinc—besides the abundant quartz, jasper, and halloysite—was formed by the action of the alkaline silicates of the springs on acid metallic emanations. The carbonates of zinc, lead, iron, and manganese, originated in consequence of the decomposition of soluble metallic sulphates or chlorides by limestone or dolomite. The hydrated oxides were precipitated by the contact of the carbonates which had remained in solution with the atmospheric air. The temperature of the springs exercised a remarkable influence on the hydrated condition of the ores. Willemite, carbonate of zinc, anhydrite, quartz, and red-iron-ore were formed at a high temperature, and consequently the first; silicate of zinc, zinconite, gypsum, opal, and iron-ochre, on the other hand, formed as the temperature of the springs decreased. Delanoue applies this deduction to the coloration of the Triassic sandstones, variegated marls, &c. The formation of calcareous spar from bicarbonate of lime—produced by the hydrochloric acid so abundantly developed in volcanic emanations—took place only after the decomposition of the limestone, by metallic solutions, had ceased. The sand, clay, and breccias found in the calamine workings, are the various matters collected together in the channels of the springs. The epoch of these old and new springs belongs to that of the rock-system of the Netherlands; but in the shales and many other rocks, the springs filled the fissures with metallic sulphides, and formed veins, whilst they widened these fissures and deposited calamine only in the limestones.—The latter ore, therefore, is only met with in association with the Devonian or Carboniferous limestones, and not in the slates or sandstones; and if it occur most abundantly at the junction of the two, this arises from the lines of greatest dislocation being situated at these points.

Krug von Nidda(1), in a treatise on the ore-beds of the Muschelkalk and Dolomite of Upper Silesia, arrives at perfectly analogous conclusions. The zinc-ores which occur there consist of carbonate of zinc, hydrous silicate of zinc, and zinc-blende. Besides these, chloride of lead, carbonate of lead, galena, pyrites, and pyrolusite, with manganese and the carbonate of manganese, are also met with. The outlet channels of the springs are in several places wonderfully distinct, and Krug has given a highly instructive section of one of these. Whether the springs were connected or not with volcanic phenomena, Krug leaves undecided; but a mass of protruded melaphyre in the neighbourhood has yielded a remarkable amount of zinc. These deposits are not entirely confined to the dolomite; a convincing proof of the correctness of their assumed origin. The springs held chloride

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(1) Zeitschrift der Deutschen Geolog. Gesellsch. II, 206; Froriep's Tagesberichte über die Fortschritte d. Nat.- u. Heilk. 1850, No. 310.

Formation  
of  
calamine  
beds.

of lead in solution, which was changed by the carbonated salts into cerusite, either at the place of deposition, or on its passage thither. Pseudomorphs of this kind are found, and have also been described by Krug(1). The oxide of zinc was held and carried up in combination with carbonic acid, and its separation was promoted by the lime of the calcareous clays in which it commonly occurs. The silica-compound is explained by the action of soluble silica on the carbonate; and the frequent occurring hornstones, flint, and halloysite, sufficiently demonstrate the presence of this substance. The shallow undulations, in the dolomite, now filled with ore, were favourable to the deposition of this, as were also the impenetrable beds of clay which lie between the limestone and dolomite. The fissured condition of the latter also conduced to this end, whilst the coaly bituminous substances in its lower strata served for the reduction of the metallic sulphates. The lead-salt may likewise have existed in another soluble condition subsequently converted into anglesite by contact with sulphates. Krug believes that soluble chloride of lead was the original substance in question, and that by contact with sulphate of magnesia an exchange of acids was effected. Sulphate of magnesia does, in fact, occur in the dolomite of Upper Silesia. The formation of the calamine and iron-ore is also due to the presence of the surrounding dolomite, as likewise that of the galena; but with this difference, that, in the case of the first-named ores, a partial or entire transformation of the dolomite into calamine or brown-iron-ore took place during the process. Krug considers that these formations were contemporaneous, although separated and deposited in different spots, owing to their peculiar qualities, and to the influence exerted upon them by the contact of the bounding rock. The separation is, however, nowhere complete, for the calamine and galena are mixed with and pass into the iron-ore everywhere.

Monheim had already shown at an earlier period(2)—from a series of interesting experiments on the solubility of zinc-salts in water containing carbonic acid, and on the artificial production of silicate of zinc—that the deposits of zinc-ore were of aqueous formation. From these experiments also he drew the conclusion, that willemite was first deposited, and afterwards, in succession, silicate of zinc, carbonate of zinc, carbonate of iron with carbonate of zinc, and lastly, ferruginous calcespar containing also a little zinc. He has likewise proved that the oxygen-compounds were not derived from blende—in which case the sulphate of zinc, thus formed, would have

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(1) *Zeitschrift der Deutschen Geolog. Gesellsch.* II, 126; see page 525 of this Report.

(2) *Verhandl. des Naturh. Vereins. der Preuss. Rheinlande*, V, 127.

itself become decomposed by a solution of silicate of lime—for gypsum occurs but very rarely at Altenberg, and other sulphates do not occur there at all.

Formation  
of sulphur  
beds.

**Formation of Sulphur Beds.**—Zeuschner(1) has given a geological description of the sulphur beds of Swoszowice, near Cracow. These occur in the midst of the tertiary strata, in a marl deposit which alternates with the sulphur and with gypsum, in parallel layers. Remains of plants and dicotyledonous leaves, mostly agreeing with the fossil flora of the Wetterau, of Bilin, Parschlug, &c.(2), are met with in the sulphur; and animal remains also occur, though rarely. The sulphur is evidently an aqueous deposit from springs containing sulphuretted hydrogen. Where these springs came in contact with the atmosphere, much of the sulphur would be precipitated in the free state, or converted into sulphuric acid, and so form gypsum with the lime which was also present in the springs. These tertiary formations lie on the Carpathian sandstone, and on the Jura-limestone below. As the latter does not exhibit any of the peculiar pipes or outlet channels mentioned above, it is most probable that the springs originated in the Carpathian group. Here and there, it is true, but without the occurrence of sulphur, alterations have taken place in the Coral Rag which appear to indicate the existence of ancient springs; for the strata at these places are more strongly inclined, besides being curved, and, as it were, corroded, but this was most probably due to the action of gaseous hydrochloric acid, as no gypsum is found in the neighbourhood.

**Formation of Rock-Salt.**—Zeuschner(3) ascribes to rock-salt a double origin. The tertiary rock-salt of the northern slope of the Carpathians is a marine deposit or precipitate, whilst that of the Salzburg Alps fills up fissures in red marble, or makes its appearance in the same, like basalt or trachyte, in blocks or isolated masses, exhibiting all the characters of the product of a mud eruption, which consisted of marly clay, salt, and anhydrite. The haselgebirge (hazel rocks) of Hallein—a mixture of cubical crystals of salt, grey saliferous clay, anhydrite and variegated mail-slate—are exactly similar to the Wschiczka deposits; only the anhydrite does not constitute layers, but occurs with the saliferous clay in masses of a crystalline-granulated structure. Organic remains, which occur in the Carpathian salt-beds, are never met with in these formations.

**Artificial Formation of Metallic Sulphides.**—A reverberatory furnace, which had been in use for several years, having been pulled down

(1) Naturwiss. Abhandl. Herausg. v. Haidinger, III, 171, Bull. Géol. [2] VII, 715, Ann. Min. [4] XVIII, 125.

(2) F. Unger's Blätterabdrucke aus dem Schwefelbuche von Swoszowice; s. Naturwiss. Abhandl. Herausg. v. Haidinger, III, 121.

(3) Froberg's Berichte über die Fortschritte der Nat. u. Heilk. 1851, 294, from the Jahrb. d. österr. Geolog. Reichsanstalt.

Artificial  
formation  
of metallic  
sulphides.

at the Mulden smelting-works, Cotta observed(1) that the entire mass of its walls was traversed in all directions by the most beautiful metallic veins. These were not only present along the original joints of the stones, but also in after-formed cracks; and their sides exhibited the phenomena of impregnation and alteration, exactly as seen in the boundary-walls of natural veins. The ores thus formed were sulphides, and consisted, so far as could be ascertained by simple inspection, of galena, blende, pyrites, copper-pyrites, purple-copper, fahl-ore, native copper, &c.; but Plattner has undertaken their analysis. Besides these, various crystallizations and reticulated forms were observed. Cotta mentions these facts in answer to the opposed views of G. Bischof, that metallic veins can only originate in the wet way. He leaves it undecided whether the veins were filled by sublimation or by the gradual infiltration of molten substances but he is quite convinced that the phenomenon was not produced by any co-operation of water.

Respecting Hausmann's experiment on the artificial formation of metallic sulphides, see p. 17 of the present Report. For those of Sénarmont, also, consult p. 174.

**Feldspar Pseudomorphs, and their Formation in the Wet Way.—**

The pseudomorphs of feldspar after laumonite, originally made known by Haidinger(2), have been also discovered by G. Bischof(3) in the trap rocks of the Kilpatrick Hills. Their analysis by C. Bischof, yielded:

| Sp. gr. | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | KO.   | NaO. | CaO. | MgO.  | Fe <sub>2</sub> O <sub>3</sub> . | Loss on ignition. | Total. |
|---------|--------------------|----------------------------------|-------|------|------|-------|----------------------------------|-------------------|--------|
| 2.56    | 62.00              | 20.00                            | 16.54 | 1.07 | 0.60 | trace | 0.64                             | 0.87              | 101.72 |

The lime of the laumonite is here exchanged for potassa, a little silica added, and the water eliminated: to effect which, a silicate of potassa with 3 atoms of potassa and 4 of silica is sufficient—assuming that potassa is capable of replacing the lime. This assumption is borne out by Berzelius's analysis of a flint knife-blade, the weathered surface of which contained potassa, and the internal unaltered portion, lime(4). Silicate of lime, however, is also decomposable by carbonate of potassa into silicate of potash and carbonate of lime(5).

G. Bischof considers himself warranted in attributing an aqueous origin to feldspar, from the occurrence of this mineral in metallic veins—these latter, in his opinion, being only formed in the wet way. A specimen of this kind, from Schemnitz, was found by C. Bischof to consist of:

| SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | KO.   | NaO. | CaO. | MgO. | Fe <sub>2</sub> O <sub>3</sub> . | PbO & CuO. | Loss on ignition. | Total. |
|--------------------|----------------------------------|-------|------|------|------|----------------------------------|------------|-------------------|--------|
| 64.00              | 18.00                            | 15.43 | 0.79 | 0.78 | 0.31 | 0.54                             | 0.32       | 0.53              | 100.70 |

(1) Jahrb. Miner. 1850, 432.

(2) Jahrb. Miner. 1850, 44.

(3) Wien. Acad. Ber. 3 Heft.

(4) Bischof's Chem. Geol. II, 419.

(5) Bischof's Chem. Geol. II, 420.

G. Bischof also looks upon the occurrence of feldspar in sedimentary formations, as in clay-slate and grauwacke(1), and especially in the schistose altered porphyry from the district of the Lenne, in which the tail-portion of a trilobite (*homalonotus*) was found(2), as farther corroborations of his hypothesis.

Presence  
of water in  
feldspa-  
thic rocks.

**Presence of Water in Feldspathic Rocks.**—Rammelsberg(3) has contested the views of Delesse(4) in regard to the water in the feldspar of feldspathic rocks being an original constituent. Delesse assumes, that in rocks, which are in a state of decomposition, the water is not so strongly united, as it is in chemical compounds; and he cites the clays as a proof of this. Rammelsberg, however, remarks that the process of decomposition in the mineral kingdom produces by no entire substance an actual mechanical mixture, but only a mixture of rate compounds, in which the water is in chemical combination. Not only is the retention of the hygroscopic water in porous bodies of this kind very great, and a high temperature requisite for its elimination, but the clays contain also chemically-combined water; and to both is due the continued loss which takes place on ignition. In this manner, the water which, in the melaphyres, is not driven off at 100°, cannot be considered without farther inquiry as existing in chemical combination. The fact that the most ancient rocks contain the lowest amount of water, is no proof that this water did not arise from weathering. It is not the age of the rock; but the presence in it of lime silicates, on which its alterability mainly depends; and thus the newer rocks containing a basis of oligoclase and labradorite, decompose the easiest. Rammelsberg also opposes the assumption of Delesse, that basalt gelatinizes only occasionally in acids, and that it contains no zeolites. This gelatinization is, in fact, a definite character of all true basalts; and, from the nature of the bases which dissolve out, it is evident that the presence of olivine is not the cause of the phenomenon. Rammelsberg cannot believe that red-hot fluid lava contains water; and doubts this also, in regard to the plutonic formation of feldspathic rocks. The lava might, however, absorb moisture during cooling. The transparency and distinct cleavage of the feldspars which contain water, is no absolute proof that these minerals retain their original condition.

**Pseudomorphs of Serpentine after Augite.**—L. Liebener and Haidinger(5) have described some pseudomorphs after augite (fassaite, pyrgome), from the Monzoni rocks. These are of extreme interest, from the light which they throw on the formation of serpentine. They constitute gigantic crystals, composed, however, of a number of smaller ones which consist, when unaltered, of fassaite and

(1) Jahrb. Miner. 1849, 187.

(2) Karsten's Arch. XIX, 419.

(3) Zeitschrift d. Deutschen Geolog. Gesellsch. II, 24.

(4) Annual Report for 1849, 560; Zeitschrift d. Deutschen Geolog. Gesellsch. II, 18.

(5) Haidinger's Berichte (see p. 477), VI, 77.

Pseudo-  
morphs of  
steatite  
after flint.

white steatite ; and when weathered, of ophite and light-brown steatite. Frequently one-half of the crystal consists of pyrgome, and the other half of the most beautiful ophite.

**Pseudomorphs of Steatite after Flint.**—According to G. Rose(1), nodular masses occur in the gypsum of Stecklenberg in the Hartz, which in appearance and colour resemble flint ; but which are greasy to the touch, and sufficiently soft to be scratched easily by the knife. On ignition, they burn white. With these, also, casts of the spatangus coranguinum (Micraster, Ag.) are likewise met with, as in the neighbouring chalk. The gypsum rests upon a yellowish, sandy, earthy-looking limestone, traversed in all directions by small, spathose veins, and having exactly the appearance of dolomite. Frapolli(2) announced his belief some time ago, that the nodules had once been actual flint, and that they belonged, together with the supposed dolomite, to the chalk formation. Th. Bromeis and Rosengarten(3) have now examined these various matters. Bromeis finds that the nodules consist of steatite, and are therefore pseudomorphs after flint(4) ; but that the earthy limestone is not a dolomite. According to Rosengarten, this latter has the following composition: Carbonate of lime, 88·76 ; sulphate of lime, 0·33 ; protoxide of iron, 1·06 ; alumina, 0·35 ; insoluble silicate, 9·49 ; total, 99·99. The 9·49 per cent of insoluble silicate, consisted of : lime, 0·98 ; alumina and sesquioxide of iron, 2·51 ; silica, 6·00 = 9·49. Rosengarten also found in the spar veins : carbonate of lime, 87·57 ; carbonate of magnesia, 11·27 ; sulphate of lime, 0·60 ; alumina and sesquioxide of iron, 0·43 ; silica, 0·21 ; total, 100·47.

**Formation of Agate Amygdalites(5) in Melaphyre.**—Nöggerath(6) has investigated in detail the subject of the amygdaloidal agate cavities occurring in the melaphyre of the Nahe district, and in the same rock in Brazil(7). His two papers on this subject are accompanied by explanatory figures. The result of these investigations corroborates the opinion principally set forth by L. von Buch, that the cavities were formed by bubbles of steam or gas, rising, in accordance with the laws of gravity, through the molten and soft pasty mass of the melaphyre. Notwithstanding numerous modifica-

(1) Zeitschrift d. Deutschen Geolog. Gesellsch. II, 136.

(2) Annual Report for 1847 and 1848, II, 501.

(3) Zeitschrift d. Deutschen Geolog. Gesellsch. II, 137.

(4) See page 485.

(5) The term amygdaloid being applied by English geologists to the entire mass of the rock, that of *amygdalite* is employed in the present Report to designate the substance of the amygdaloidal cavities.

(6) Naturwiss. Abhandl. Herausgegeben v. Haidinger's, III, 93, 147 ; Haidinger's Berichte (see p. 477) VI, 62.

(7) At this moment, principally the so-called Brazilian agates are worked at Oberstein. These occur as river pebbles in a tributary of the Rio de la Plata, near Monte Video, and belong also, as Nöggerath has shown, to melaphyre. The trade at Oberstein is now in a very flourishing state, and includes the artificial colouring of these stones, as well as the manufacture of the most beautiful imitations of mocha-stone and moss-agate.

tions, a common normal shape, in almost every instance, may be traced in these cavities. This is very nearly pyriform, but partially flattened on one side, so as to have its lower pointed extremity more or less extended into an edge. The deviation from the exact pyriform shape, in the expanding bubbles, was effected by the lateral pressure to which they were exposed in their ascent; and thus—as well as by the breaking into one another of two cavities, in many cases only to be traced by a notch or furrow at the surface—various distorted forms have been produced. A parallelism in the direction of their length, with the sharp cuneiform edge turned downwards, such as von Buch observed at Ilfeld, was not perceptible in the cavities examined by Nöggerath.

Formation  
of agate  
amygda-  
lites in  
mela-  
phyre.

It is evident from the contents of the double cavities mentioned above, that these were filled after the two cells had become united, as the concentric layers of the included substances have been deposited around the entire outline of the hollow space, and are modified according to the original form of the separate cavities. A farther proof of this is afforded by the fissures, which frequently pass across the cavities, so as often to be the cause of fractures, but without affecting in any way the matters contained therein. Examples, however, also occur, in which fissures have taken place after the filling of the cavities. In these cases, fragments are often broken off at the fissured edges, and the fissures themselves have been generally re-filled with quartz. The greater part of the amygdaloidal cavities in the rocks of the district of the Nahe, are occupied merely by calcareous spar; but their walls have usually a coating of green-earth, which Nöggerath considers to have been derived by weathering from the melaphyre itself. The siliceous and zeolitic contents are only of local occurrence, and these never entirely exclude the presence of carbonate of lime. The cavities in the upper portions of the rock are commonly empty, whilst in the deeper valley-sections they are filled with calcareous-spar. The siliceous-matters appear likewise in the open spaces produced by contraction, and in general fissures. This applies also to the other minerals occasionally present in these rocks.

Nöggerath does not look upon the silica as a product of decomposition derived from the melaphyre by the agency of atmospheric water, because these amygdalites are met with in the least-altered rocks, and cannot consequently depend on any particular degree of disintegration to which the melaphyres may have been subjected. He considers, furthermore, that the filling process, in regard to cavities of this kind, is no longer in action. These matters, in his opinion, were produced by carbonated and thermal springs which broke out from fissures in certain localities during the cooling of the melaphyre—the formation of the amygdaloidal substances terminating with the complete refrigeration of the rock and the cessation of the springs.



Formation  
of agate  
amygda-  
lites in  
mela-  
phyre.

Nöggerath assumes, moreover, that in regard to the agate cavities, channels of infiltration have always existed; and he denies that the enclosed matters have originated from the permeation of mineral solutions through the walls of these cavities, although he allows the possibility of permeation taking place through such apparently compact substances. He finds a strong proof in favour of this view, in the fact, as seen in the artificial colouring of the amygdaloidal chalcodones, that certain layers, permeable to liquids, alternate with others which are quite impermeable; so that a deposition of matter from the exterior to the interior, could not here possibly take place. He also affirms, in farther corroboration of this view, that in almost every amygdaloidal cavity, whether still open or filled up, the passages may be traced by which the solution entered it. Very many of these are frequently observable. All the concentric layers proceed from the edges of such passages, and are even arranged beyond them. In the Brazilian amygdalites, the concentric bands pass into horizontal layers at the under part of the nodules, and become, where this change takes place, very thick. This thickness is explained by the supposition that in the formation of the concentric bands, only the forces of adhesion and crystallization are brought into play; whereas, in the horizontal arrangement, the action of gravitation is also felt. Horizontal layers of this kind are never found in the district of the Nahe, but are of general occurrence in other countries.

Haidinger, who originally considered that the formation of amygdalites was effected, not by any definite points of infiltration, but by the general permeation of mineral solutions through the walls of the cavities, now adopts the views of Nöggerath(1).

**Cause of Impressions on Rolled Stones as found in certain Conglomerates.**—Paillette(2), from some experiments and observations on the siliceous pudding-stones of Mieres, has sought to explain the formation of those enigmatical rolled-stones which occur in many conglomerates; amongst others, in those of the coal-measures(3). These stones frequently exhibit a starlike fracture, and are again cemented together. Many also are marked with impressions of other pebbles. At Mieres, it is seen that a somewhat feldspathic sand lies beneath the pudding-stone, and beneath this, a finely-laminated shale, and then coal. Paillette assumes that the following results took place: First, the feldspar grains became decomposed by the action of carbonic acid developed in the coal-beds. Secondly, moisture containing alkalis or alkaline carbonates, penetrated the conglomerate, the pebbles of which had become somewhat softened by a high temperature. In this condition, as Paillette has shown by experiment,

(1) Haidinger's Berichte (see p. 477) VI, 62.

(2) Naumann's Lehrb. d. Geognosie, I, 449.

(3) Bull. Géol. [2] VII, 37.

only a slight pressure of the superincumbent mass would be required to effect their fracture, and to produce the slight impressions with rough surfaces, which many of them exhibit. If these impressions had resulted from pressure alone, their surfaces would have been smooth. It is supposed that the feeble disturbing movements which accompanied the first elevation of the coal strata, were sufficient to produce the above effect. Finally, the separate pebbles were afterwards united by a siliceous cement.

Cause of impressions on rolled stones as found in certain conglomerates.

Favre(1), in support of this view, adds that a softening of the stones by the moisture contained in rocks, as here assumed, is a perfectly legitimate deduction; because, in the digging up of old rubbish-heaps, fragments of glass have been found in a softened state. On exposure, these quickly resume their ordinary condition.

**Mode of Formation of Calcareous Stalactites.**—According to M. J. Vogel(2), the stalactites of the Adelsberg cavern are hollow in some specimens, and solid in others; and with, as well as without, a drusy crystallization at their surface. The formation of the tubular stalactites is explained by the unevenness of the roof from which the water trickles. The precipitate, produced by evaporation, is less abundant at the points of the projections, where the drops flow together and fall down, than at the sides of these, nearer to the roof. Around the base of each projecting point, therefore, a ring is formed; and this, increasing, produces a hollow stalactite. These tubular forms are generally clothed in their interior with delicate crystals; partly because the deposited matter hardens there very gradually; and also, on account of this internal part being protected from the action of the constantly dripping water, and thus favourably disposed for crystallization. On the external surface, on the contrary, crystals are prevented from forming by the little streams of water which are continually trickling over it; and it is only when this action ceases, that the crystalline coating is developed. The effects of the trickling water are generally perceptible on the surface of the stalactites, in the form of striæ and shallow groovings.

**Dependence of Vegetation on the Physical Qualities of Rocks.**—We can here but briefly call attention to the important work of Thurmann(3), which appertains in common both to Geology (or rather Petrology) and Botany; and which embraces a large number of facts derived from the Jura chain and the surrounding countries. Thurmann considers that the habitations and stations of plant groups, depend almost exclusively on the physical qualities of soils, without,

(1) Bull. Géol. [2] VII, 44.

(2) Haidinger's Berichte (see p. 477) V, 8.

(3) Essai de Phytostatique appliquée à la Chaîne du Jura et aux Contrées Voisines, ou Étude de la Dispersion des Plantes Vasculaires envisagée principalement quant à l'Influence des Roches sous-jacentes, 2 Vols., Berne, 1849; noticed in detail in the Arch. Ph. Nat. XIV, 73.

Depend-  
ence of  
vegetation  
on the  
physical  
qualities  
of rocks.

however, denying a certain influence to the chemical properties of soil-producing rocks, especially of those formed of easily soluble salts; and he admits that these chemical properties play an important part in agriculture. He arranges all rocks under two heads. The first comprises those which exhibit a certain kind of disintegration, possessing, as specimens, a hygroscopic nature, and being permeable to water in the mass; whilst the second includes those of a totally opposite character. Each of these divisions is represented in rocks of all kinds of chemical properties. The rocks of the first division are termed by Thurmann, *roches Eugéogènes* (good earth-producers); and these he subdivides into *psammogènes*, (sand-producing rocks), and *pélogènes* (clay-producing rocks). Those of the second division, he designates as *roches dysgéogènes* (bad earth-producers). The plants which affect the first group are termed "water-loving plants" (*plantes hygrophiles*); and those appertaining to the second, "dry-loving plants" (*plantes xérophiles*).

These views of Thurmann have been vigorously attacked by several members of the Geological Society of France(1)—by Rivière, Michelin, Wegmann, Delesse, Boubée, and Elie de Beaumont, amongst others—all of whom maintain the predominating influence of the chemical nature of the soils. To the objection of the latter, that a great similitude exists between the vegetation of very dissimilar rocks, as the Jura limestone and the basaltic and doleritic rocks of the Kaiserstuhl; and that, in this particular case, the similarity of vegetation is caused by the silicate of lime in the latter sustaining the part of the carbonate of lime in the former—Thurmann has replied(2): that on the Kaiserstuhl the vegetation becomes the more jurassic—i. e., lime-affecting—the less the rock is decomposed; and, on the contrary, the less jurassic, the greater the decomposition of the rock, or when consequently, according to this hypothesis, the lime should be best able to exert upon the vegetation its supposed influence.

**Unstratified Rocks. Formation of Granite.**—Durocher(3) has defended his opinion of the igneous origin of granite(4) against the objections of Schœrer(5). For details, we must refer to the communication itself.

**Granitic Rocks.**—G. Rose(6) has more accurately defined the various rocks belonging to the granitic group, besides giving the natural-history characters of each of these. He places five kinds of rock in this division: 1. granite; 2. granitite; 3. syenite; 4. porphyry; and 5. syenite-porphyry. These consist principally of

(1) Bull. Géol. [2] VII, 111.

(2) Ibid. 474.

(3) Ibid. 276.

(4) See Annual Report for 1847 and 1848, II, 481.

(5) See Annual Report for 1849, III, 561.

(6) Zeitschrift d. Deutschen Geolog. Gesellsch. I, 352.

mixtures of six minerals: orthoclase, oligoclase, quartz, white (potassa) mica, black (magnesia) mica, and hornblende, besides a few other unessential constituents. Rose remarks, that the orthoclase (feldspar) of the granitic group always contains a small quantity of soda, and a still smaller quantity of lime. The oligoclase occurs pretty frequently in regular union with the orthoclase. Both have the principal axis and  $(\infty P \infty)$  in parallel positions; and the oligoclase entirely surrounds the orthoclase, so that the cleavage-faces  $OP$  of the two lie nearly in one plane. The oligoclase may be recognized by its striæ. The potassa-mica is silvery or yellowish-white, and occurs in leaves of irregular form; occasionally, also, in distinct rhombic tables. The magnesia-mica is between dark pinchbeck-brown and pitch-black, or between dark leek-green and greenish-black, and slightly transparent. It occurs in irregular leaves, but also, and more frequently than the white mica, in regularly formed tables, which in this case are hexagonal. These two kinds of mica are often united in a very regular manner, so much so indeed, as not to interrupt the direct course of the cleavage, which passes through the entire mass. The white mica forms also a kind of border to the brown.

The unessential constituents present in this group of rocks, consist of: garnet (apparently a ferrugino-aluminous species); zircon; iolite (commonly decomposed, and converted into pinite; Rose, indeed, states that he has not yet observed it in these rocks, in the unaltered condition); nepheline; orthite; polymignite; pyrochlore; titanite, apatite; magnetite; specular iron; pyrites; copper-pyrites, and molybdenite(1).

**Granite.**—This consists of white, or very rarely of reddish-white or flesh-red orthoclase, quartz, white potassa-mica, black magnesia-mica, and a subordinate amount of oligoclase. Hornblende, garnet, orthite, titanite, apatite, and pyrites, occur as unessential constituents. Rose adopts the following subdivisions: 1. Granite, with orthoclase, quartz, brown and white mica, and a little oligoclase: *Ex.*, granite from the Schwarzbrenner Berg. 2. Granite, with orthoclase, quartz, brown mica, an abundance of oligoclase, and a small quantity of white mica: *Ex.*, granite from Lausitz. 3. Granite, with orthoclase, quartz, brown mica, little or no oligoclase, and no white mica: *Ex.*, granite from Striegau, Guhlau, and Qualkau, Elnbogen. 4. Granite, with orthoclase, quartz, and white mica, but without either brown mica or oligoclase: *Ex.*, granite from Gurkau on the Zobten.

**Granitite.**—Under this term, Rose separates from granite, a rock consisting of orthoclase, quartz, and magnesia-mica. The orthoclase,

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(1) Other minerals also occur in the druses, but Rose makes no allusion to these. It need scarcely be mentioned, however, that such are of especial importance in regard to the mode of development of granitic rocks; and on this account it could have been wished that the author had taken into consideration the entire series of substances.

**Granitite.** in contradistinction to that in granite, is commonly of a red colour, being either flesh-red, brownish-red, or tile-red. The oligoclase is of the same colour as that in granite; and, as a general rule, of a different colour to the orthoclase. Hornblende, orthite, zircon, titanite, pyrites, copper-pyrites, and molybdenite, occur as unessential ingredients. Granitite forms the principal mass of the Riesengebirg, of the Isergebirg, of the Brocken, &c. It appears to be always of newer formation than granite.

**Syenite.**—This consists of orthoclase, oligoclase, hornblende, magnesia-mica, and quartz. The orthoclase is chiefly of a reddish colour, commonly brownish-red, but occasionally also white. Brownish-red is likewise the prevailing colour of the oligoclase(1). The hornblende is greyish-black, by which it is distinguished from the hornblende of diorite, the latter being generally of a greenish-black colour. Titanite, apatite, and magnetite, belong to the unessential constituents of more general occurrence; and zircon, nepheline, polymignite, pyrochlore, &c., to those less commonly met with. The essential constituents, however, are not simultaneously present in every variety, so that Rose brings the rock into four subdivisions: 1. syenite, consisting of only orthoclase and hornblende (Friedrichsvärn); 2. of orthoclase, oligoclase, and hornblende (Plauen'scher Grund); 3. of orthoclase, oligoclase, hornblende, green mica, and quartz, or this without the hornblende (Radowitz near Meissen); 4. of orthoclase, oligoclase, and green mica (Polaun and Altenberg).

**Porphyry (Felsite-Porphyry).**—This consists of orthoclase, oligoclase, quartz, and magnesia-mica, in a basis which seems to G. Rose to be an intimate mixture of the same constituent minerals—these having, in part, separated from the general mass, in larger crystals. The unessential constituents comprise: iolite (decomposed into pinitite), garnet, orthite, and pyrites. Rose adopts for porphyry three subdivisions: 1. porphyry containing all four ingredients in large and numerous crystals (Autun, Altenberg in Silesia), the variety which generally occurs in granite or granitite; 2. porphyry containing all four constituents, but mostly in small crystals, and with the mica sparingly, or not at all, present (Wettin and Löbejün near Halle); 3. porphyry containing only feldspar and quartz (Botzen and Monte Video).

**Syenite-Porphyry.**—This consists of a basis with enclosed crystals of orthoclase, oligoclase, magnesia-mica, and hornblende. It differs, therefore, from the felsite-porphyry by the absence of quartz. Rose places here the rhombic porphyry of Leopold von Buch, the hornstone- and curite-porphyry of Keilhau and others, the Wildsruff-

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1) G. Rose considers the feldspathic mineral, which occurs with orthoclase in the syenite of the Vosges, to be a decomposed oligoclase. Delesse has attributed it to andesine. See Annual Report for 1847 and 1848, II, 410.

porphyry of Naumann, and the mica-porphyry of Cotta. The basis is of various brownish-red, reddish-brown, blackish-grey, and greyish-black colours; and exhibits a fine splintery, passing into an uneven, fracture. The orthoclase of the syenite-porphyry of Southern Norway, does not possess the otherwise constantly prevailing planes ( $\infty P \infty$ ). The crystals, in other respects, are bounded at the ends by  $+2 P \infty$ ; and the planes  $0 P$  either fail entirely, or are only present as a subordinate form. These crystals are, also, sometimes simple, and sometimes in twin-forms; and the latter are remarkable, in respect to their planes of junction being a face of  $\infty P \infty$ . The planes of fracture, therefore, in this orthoclase, if the section be parallel to  $0 P$ , appear as rhombs of about  $116^\circ$ ; or as equilateral triangles, if the section pass through  $\infty P$  and  $0 P$ ; or, furthermore, as symmetrical hexagons, if it pass through the upper and lower terminating planes, where several of these are present. The section parallel to ( $\infty P \infty$ ) appears as a rhomboid of  $144^\circ$ . On account of these rhombic and rhomboidal sections, the rock has received from L. von Buch the name of rhombic porphyry(1). The unessential constituents comprise: garnet, nepheline, titanite, quartz, magnetite, specular-iron, and pyrites.—The whole of the essential constituents are not always present together, in consequence of which a great number of varieties occur. The syenite-porphyry is less ancient than syenite which it traverses in veins.

Syenite-  
porphyry.

**Granite.**—The granite of the Valorsine, described by Saussure, Necker, Lyell, and Fournet, and which occurs in a series of nearly parallel veins, three feet thick, in gneiss, has been analyzed by Delesse(2). Its constituent minerals consist of quartz, light grey orthoclase, pearl-white or somewhat greenish oligoclase, apparently identical with that of protogine, and two kinds of mica (pinchbeck-brown and silver-white) which often pass into one another in the same scale or folia. The analysis in the mass yielded:

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | CaO. | NaO, KO, MgO.* | Loss on ignition. | Total. |
|--------------------|----------------------------------|----------------------------------|------|----------------|-------------------|--------|
| 75.00              | 12.90                            | 1.10                             | 1.26 | 9.34           | 0.40              | 100.00 |

\* Determined from the difference.

In its composition this granite very closely resembles the protogine from the summit of Mont Blanc. The latter rock merely contains a little more iron and magnesia(3).

According to Alluaud(4), the granite of the environs of Chanteloube (Haute Vienne) contains as essential constituents, quartz, orthoclase, albite, and several kinds of mica, amongst which may be cited,

(1) See page 491.

(2) Bull. Géol. [2] VII, 424; Arch. Ph. Nat. XIV, 157.

(3) See Annual Report for 1847 and 1848, II, 493.

(4) Bull. Géol. [2] VII, 229.

Granite.

a black, ferruginous mica, a violet-manganesian mica, and a lithia mica. This granite frequently occurs in rounded masses of from 50 centimetres ( $19\frac{1}{2}$  inches) to 1 or 2 metres (6·56 feet) in diameter, but the contiguity of the separate masses has interfered with their mutual development. The nucleus of each consists of a lamellated feldspar. This is surrounded by a fine granular feldspathic substance (eurite), containing irregular fragments of quartz ( $\frac{2}{3}$  of a cubic inch in bulk) arranged in well-defined concentric zones. After this occurs a second zone of still smaller particles of quartz; and finally, a third and fourth zone, in which the quartz granules gradually decrease in bulk, to the size of a pin's-head. In the interior of these granite spheroids, and enclosed in albite, the following minerals occur: apatite mixed with garnet, pharmacosiderite, mispickel, common and tantaliferous wolfram, columbite, and crystallized and decomposed beryl. The latter forms a true kaolin. Damour(1), who has analyzed this product, believes that the elimination of the berylla, corrects that earth with the monatomic bases expelled in the formation of the feldspar kaolins.

**Syenite.**—Delesse(2) has examined the bright red syenite(3) which occurs in Egypt. It consists of quartz, orthoclase, oligoclase, mica, and frequently hornblende. The quartz is transparent and of a grey colour, with sometimes a slightly violet or smoky tint, arising from the presence of a minute quantity of organic matter. The orthoclase is of a bright, lively red, red, or yellowish-red; and its spec. grav. = 2·568. It is the predominating constituent. On ignition it loses only 0·35 per cent; and by weathering, it assumes occasionally a brown colour caused by the presence of a little oxide of manganese. The triclinometric feldspar or oligoclase is white, but sometimes becomes yellowish or even greenish. In some specimens of syenite it is even more abundant than the orthoclase. The mica is black, or occasionally brown and green. It is rich in magnesia and iron, and is frequently associated with hornblende. The minerals present as occasional constituents, consist of pyrites, magnetite, and garnet. Delesse has determined according to his method(4) the proportionate volumes of the true constituents. He found these to be as follows: red orthoclase 43, grey quartz 44, white oligoclase 9, black mica 4. The rock exhibited in the mass the following composition:

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> .* | CaO. | KO, NaO, MgO.† | Loss on ignition. | Total, |
|--------------------|----------------------------------|-----------------------------------|------|----------------|-------------------|--------|
| 70·25              | 16·00                            | 2·50                              | 1·60 | 9·00           | 0·65              | 100·00 |

\* Containing manganese.

† Determined from the loss.

(1) See page 499.

(2) Bull. Géol. [2] VII, 484; Jameson's Edinb. New Phil. Journ. L, 260.

(3) Strictly, a granite, only occasionally containing hornblende, and thus forming a transition from the granite into the syenite series. In commerce it bears the name of red oriental granite.

(4) See Annual Report for 1847 and 1848, II, 454.

This syenite is traversed by diorite-veins, a phenomenon witnessed also in other localities. Delesse believes, from this circumstance, that the elaboration of hornblende in the rock, is intimately connected with the filling up of these veins; or, that the phenomenon has taken place, in fact, by metamorphic action, subsequent to the formation of the rock itself.

**Felsite-Porphry.**—Delesse(1) has also examined the ancient red porphyry of Egypt. \* Respecting the feldspar of this rock, see p. 492. of the present Report. In its composition, it mostly agrees with oligoclase. \* The spec. grav. of the basis of the porphyry = 2.765. With acids, only a very feeble effervescence is occasioned. In *a*, in the following analyses, decomposition was effected by carbonate of soda, and in *b*, by hydrofluoric acid:

|          | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> .* | CaO. | MgO. | NaO. | KO. | Loss on ignition. |
|----------|--------------------|----------------------------------|-----------------------------------|------|------|------|-----|-------------------|
| a. 62.17 | 14.91              | 7.59                             | 3.28                              | —    | —    | —    | —   | 0.58              |
| b. —     | 14.30              | 8.00                             | 3.32                              | 5.00 | 4.10 | 2.04 | —   | —                 |

\* Containing a little manganese.

This porphyry contains small crystals of hornblende, which stand out very distinctly from the basis. \* Under the microscope, feldspar is perceived between lamellæ of these, indicating for both a simultaneous formation. Besides the specular-iron already detected by Cordier and G. Rose(2), Delesse assumes the presence of a little magnetic-iron. Quartz is very rarely present, and when it occurs it is in small irregular veins, never in granular masses. The red, antique porphyry consists, therefore, almost entirely of a feldspathic basis, with crystals of one of the feldspar minerals—probably oligoclase. The spec. grav., 2.727 as determined by Brard(3), was found by Delesse = 2.763. By fusing the porphyry in a glass furnace, the spec. grav. decreases to 2.486. The rock has frequently a brecciated structure; but the angular fragments are only varieties of the porphyry itself. These are sometimes quite distinct from the basis, and at other times pass imperceptibly into it. The resistance of the present rock to mechanical destruction, compared to that of the Egyptian rose-coloured syenite, is as  $2\frac{1}{2} : 1$ . The analysis of the bright-red specimen, employed in determining the spec. grav. yielded: silica 64.00 per cent, lime 3.5, loss on ignition 0.29, or, 2 per cent of silica beyond the amount found in the violet-red basis. The latter also always contains more quartz.

A similar porphyry occurs in several parts of the Vosges, especially near Kirschberg, in the Vallée de Massevaux (Haut Rhin), and on the right bank of the Dole. Greenish and brownish-black varieties occur at the foot of the Belchen, near Giromagny, Framont, &c. The beau-

(1) Bull. Géol. [2] VII, 524; Ann. Ch. Phys. [3] XXX, 81.

(2) Reise nach dem Ural, I, 561, 564.

(3) Traité des Pierres Précieuses, Part II, 526.



Felsite-  
porphyry.

tiful porphyry of Elfdalen is also well known to belong to this division. Delesse has examined one of a similar kind from Rennås, which contained small crystals of reddish orthoclase, greenish crystals of a trichinometric feldspar, greenish-black hornblende crystals, and numerous grains of steel-grey specular-iron. Its spec. grav. = 2.623. With acids it scarcely effervesced. The trichinometric feldspar exhibited the characters of oligoclase. The analysis in the mass yielded:

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> . | CaO, MgO. | Alkalies.* | Loss on ignition. | Total. |
|--------------------|-------------------------------------------------------------------|-----------|------------|-------------------|--------|
| 77.99              | 15.00                                                             | 1.00      | 6.00       | 0.01              | 100.00 |

\* Determined from the difference.

Delesse(1) has examined, furthermore, the feldspar-porphyry of Lessines and Quenast, in Belgium. The feldspar of this rock appears in delicately striated white, or greenish-white twin-crystals, and belongs to oligoclase(2). Exactly the same substances occur in the massive, greyish, and dark green basis, as in the feldspar, but in different proportions. The green colour arises from the presence of a soft, hydrated silicate of iron and magnesia, which suffers a considerable loss on ignition (from 1.85 to 2.10 per cent), and which is readily attacked by acids. Delesse looks upon this as a pseudomorphous chlorite. The basis also frequently contains quartz, but that substance is not always present. Occasionally, a few small scales of green hornblende likewise occur in it, as well as carbonate of lime, siderose, pyrites, epidote, and other minerals. The porphyry of Lessines suffers on ignition a loss of 5.41 per cent, which can only be ascribed to the presence of the above carbonates. For the mean composition of the basis, a dark green specimen from Lessines was analyzed in which disseminated chlorite occurred. This contained:

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> . | CaO. | MgO, KO, NaO.* | HO, CO <sub>2</sub> . | Total. |
|--------------------|-------------------------------------------------------------------|------|----------------|-----------------------|--------|
| 57.60              | 25.00                                                             | 3.73 | 9.92           | 4.25                  | 100.00 |

\* Determined from the difference.

**Diabase and Diorite.**—Lory(3) has subjected some specimens of the so-called diabase and diorite from Oisans, to a chemical investigation. These rocks consist essentially of hornblende and a trichinometric feldspar. The latter is certainly not albite; but it may belong very possibly to andesite, as that mineral has been remarked by Delesse in the diorite of Fayment in the Vosges(4).

1. Diabase from the Chalanges d'Allemont (Oisans). This forms veins which belong to the oldest in the locality, and which consist of

(1) Ann. Min. [4] XVIII, 103; Bull. Géol. [2] VII, 310; Instit. 1850, 291

(2) See page 492.

(3) Bull. Géol. [2] VII, 540.

(4) See Annual Report for 1849, 527, 563.

very dark, brilliant, and strongly lamellated crystals of hornblende, frequently associated in so regular a manner with the feldspar as to produce a true graphic diabase. The feldspar occurs in small, milk-white, and scarcely translucent crystals, the lustre of which is pearly, inclining to greasy(1). It is almost always accompanied by epidote, and often indeed intimately mixed up with that mineral. This latter is vitreous, transparent, and of a pale yellowish-green colour(2). 2. Diabase with crystallized prehnite from Bourg d'Oisans. This scarcely differs from the foregoing variety, but is characterized by the presence of prehnite. Concerning its hornblende and feldspar, see pp. 487 and 493. 3. Schistose diorite. This consists also of andesite and hornblende. It is very abundant amongst the rocks of the Bourg d'Oisans district. 4. Granitic diorite. This variety occurs abundantly in the pebbles of the Drac and the Romanèche, and in the tributaries of these streams. It possesses the same composition as the above.

Delesse(3) remarks, in addition to these observations, that the feldspar in diorite is rarely albite(4) but a species poorer in silica, occasionally, perhaps referable to oligoclase, but principally to andesite. In some diorites as in that of Pont Jean, in the Vosges, the feldspar is even labradorite. In the variety from Corsica (with 48.62 per cent of silica) it consists of anortite. Delesse believes, however, that in these kinds of rock, the feldspathic minerals pass into one another, even in very limited areas, as exemplified by the euphotide of the Alps. In this latter, within the same group of rocks, the silica oscillates between 43 and 60 per cent.

**Diabase-Porphry.**—A diabase-porphry, similar to that from Rübeldand, occurs, according to F. A. Romer(5), in the Hut-valley, near Clausthal, in the Hartz. The included crystals consist of labradorite(6).

**Variolite.**—Delesse(7) has submitted the variolite of the Durance to a chemical examination. This rock was regarded by Cordier, Beaumont, and Scipio Gras as a variety of euphotide, in which the crystalline structure is not developed. The almost perfectly globular masses enclosed in its basis, vary in colour from greenish-white to greyish-green, and often assume a violet colour in their interior. By conversion into kaolin, they become brownish or white. In respect to size, they are sometimes in microscopic masses, but commonly from  $\frac{1}{4}$

(1) See page 493.

(2) See page 448.

(3) Bull. Géol. [2] VII, 546.

(4) Hornblende, albite and quartz are enumerated as essential constituents of diorite. Naumann's Geognosie, I, 519.

(5) Jahrb. Miner. 1850, 683.

(6) See page 494.

(7) Ann. Min. [4] XVII, 116; Bull. Géol. [2] VII, 427; Arch. Ph. Nat. XV, 64; Instit. 1850, 185; Compt. Rend. XXX, 741.

Variolite.

to  $\frac{2}{3}$  inch in diameter, and some even exceed 2 inches. In general, however, their outline is scarcely defined, but passes imperceptibly into the basis, although occasionally it is quite distinct, especially when the granules are of a certain size and in this case they can be separated from the substance of the rock. These globular masses sometimes occur singly, but at other times in such numbers that the basis itself is formed almost entirely of them. Their structure is, in general, simply radiated, the radii passing from the centre of the globule; but often, also, radiated and concentric, in which case a violet-red or grey nucleus is commonly surrounded by a whitish layer, and this by a dark green one. Occasionally, also, several additional concentric layers are present in the same nodule. In some again, the structure is reticulated, the radio-concentric concretions consisting of a quantity of extremely fine crystalline lamellæ, irregularly combined with one another. The basis is commonly of a uniform greenish, or dark green colour, although sometimes veined. It also assumes occasionally a reticulated structure, owing to the presence of a number of microscopic lamellæ of feldspar which cross each other in all directions. Delesse selected for analysis some apparently homogeneous nodules from a variolite of the neighbourhood of Briançon. These contained small cavities in the interior, caused by the contraction of the mass. Under the magnifying glass, several microscopic veins of calc-spar, and some specks of magnetic iron, were perceived. The colour of the nodules was a uniform greenish-grey, and in thin splinters they were transparent. When broken, neither cleavage nor crystalline structure was perceptible, but the fracture was that of a feldstone or granular feldspathic mass, with a somewhat greasy lustre. Their spec. grav. = 2.923, which is higher than that of any known feldspar. Their composition was as follows:

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | Cl <sub>2</sub> O <sub>3</sub> . | Mn <sub>2</sub> O <sub>3</sub> . | CaO. | MgO. | NaO. | KO.  | Loss on<br>ignition. | Total. |
|--------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|------|------|------|------|----------------------|--------|
| 56.12              | 17.40                            | 7.79                             | 0.51                             | trace                            | 8.74 | 3.41 | 3.72 | 0.24 | 1.93                 | 99.86  |

Notwithstanding their large amount of sesquioxide of iron and magnesia, and their feeble proportion of alumina as compared to the silica, Delesse believes that these nodules may have been derived from one of the feldspathic minerals, and most probably—from on account of the predominating amount of soda—from a triclinometric feldspar. In their amount of silica, they resemble the feldspar of the euphotide of Odern; strictly, however, they form more a feldspathic mass than a distinct mineral. Their composition is besides never constant; for, in the same nodule, the white or light green particles closely approach the composition of a feldspar, whilst those of a violet or grey colour, comprising the particles richer in iron, differ from this more or less considerably.

The variolite of the Durance contains serpentine moreover, and

Elie de Beaumont has even observed its transition into a well-characterized mass of that substance. Its accidental constituents comprise: pyrites and sometimes a little magnetic iron, with pistachio-green or greenish-yellow epidote, quartz, chlorite, and calc-spar, in strings or narrow veins. The calc-spar also sometimes forms amygdalites. These minerals are of later origin than the nodules in the variolite, for frequently broken and reunited nodules are met with, in which the cracks have been filled up with the above-named substances.

For the determination of the mean composition of this variolite, Delesse selected a specimen which consisted almost entirely of the before-mentioned little globular masses or nodules. Its spec. grav. = 2.896, or somewhat less than the nodules themselves, a fact indicating that the basis had remained, in part, in an amorphous condition. This variolite is even more difficultly fusible than granite, being only rendered pasty by the heat of a glass-furnace. By complete fusion, it forms a bottle-green glass containing numerous bubbles. The spec. grav. of this glass only amounts to 2.288. The specimen examined lost 2.03 per cent when simply ignited by the spirit-lamp; and the difference of 3.35 per cent between this and the actual loss obtained in the analysis, corresponds very nearly to the carbonic acid of the carbonates in admixture. The analysis yielded:

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Cr <sub>2</sub> O <sub>3</sub> . | FeO.  | MnO.  | CaO. | MgO. | NaO. | KO.  | Loss on ignition. | Total. |
|--------------------|----------------------------------|----------------------------------|-------|-------|------|------|------|------|-------------------|--------|
| 52.79              | 11.76                            | trace                            | 11.07 | trace | 5.90 | 9.01 | 3.07 | 1.16 | 4.38              | 99.14  |

The amount of silica, consequently, in the entire mass of the variolite, is sensibly lower than in the nodules; but, as before remarked, the composition of the latter is by no means constant. The entire mass differs also in containing a larger quantity of magnesia and sesquioxide of iron.

Gueymard(1) has published the results of an examination of the variolite of the Drac, a rock which occurs in many parts of the departments of the Hautes Alpes, and the Isère. This rock sometimes presents a uniform composition, but constitutes at other times, true variolites and amygdaloids. The basis is more or less of a dark green colour, and contains, every here and there, imbedded globular masses of the size of a pea. These, which are easily separable from the rock, consist of quartz, calc-spar, epidote, chlorite, serpentine, siderose, and green-earth or earthy augite. Specular-iron is also seen in filaments or scales. Towards the surface, the amygdaloidal cavities are empty, and the rock resembles a cavernous or slaggy lava. Gueymard considers these variolites to be eruptive rocks which have risen in a semi-fluid state, and spread themselves for some distance over the Jura

**Variolite.** beds. At the points of contact with these latter, the variolites lose in part their usual character, and become highly ferruginous; consisting, in fact, almost entirely of silica and sesquioxide of iron. Numerous analyses performed by Gueymard on the limestones, showed that these were converted into dolomite at the points of junction; and had become crumbling and friable in the interior when lying near to, or under the variolite. In these occur separately-imbbedded masses of fahl-ore, malachite, galena, blende, and bou-nnonite, but only in the altered rocks; never in the variolite itself, nor even in the adjacent grafites. Occasionally, though rarely, the variolites contain purple copper, and more frequently, iron-pyrites.

Gueymard selected for analysis, a specimen of variolite containing the fewest amygdalites. This was treated with acetic acid. Besides the lime, only a small quantity of magnesia passed into the solution. Just the same reaction took place by treatment with diluted nitric or hydrochloric acid. The residue or portion not taken up by the acetic acid, was attacked by concentrated hydrochloric acid at  $100^{\circ}$ . This dissolved the whole of the iron, a part of the alumina, and almost all the magnesia; and the residue contained gelatinous silica. Gueymard found 7.33 per cent of residue in a slaggy variolite from the "Chapeau"; and 14.34 per cent in a variolite from Avançon. The iron is present as protoxide and sesquioxide, the latter condition being due perhaps to the action of the atmosphere. The residue was treated with caustic potassa or soda. For the determination of the alkalis, decomposition was effected by means of carbonate of baryta. The variolites lose no water at  $100^{\circ}$ .

1. Variolite from the "Chapeau": Specimen occurring in the inside of a block, with amygdalites of carbonate of lime. Acetic acid dissolved out 16.24 per cent of  $\text{CaO}$ ,  $\text{CO}_2$  and 0.41 per cent of  $\text{MgO}$ ,  $\text{CO}_2$ . 2. A second specimen from the "Chapeau": slaglike, the amygdalites destroyed. The greater part of the iron at the surface present as sesquioxide. Acetic acid dissolved out 8.91 per cent of  $\text{CaO}$ ,  $\text{CO}_2$ , and 0.56 per cent of  $\text{MgO}$ ,  $\text{CO}_2$ . 3. Variolite from Avançon near Gap (Hautes Alpes); more or less variolitic. Homogeneous masses however occur, and the specimen analyzed was of that kind. Acetic acid extracted 3.55 per cent of  $\text{CaO}$ ,  $\text{CO}_2$ , which was deducted from the analysis. 4. Spilite from Champs, near Vizille (Isère): blueish-grey basis with various amygdalites. Acetic acid dissolved out 5.375 of  $\text{CaO}$ ,  $\text{CO}_2$  with traces of  $\text{MgO}$ ,  $\text{CO}_2$ . 5. Spilite from Valbonnais (Isère): greyish-violet with green specks and amygdalites of calcareous-spar. Acetic acid extracted 8.05 per cent of  $\text{CaO}$ ,  $\text{CO}_2$  with traces of  $\text{MgO}$ ,  $\text{CO}_2$ . 6. Variolite from La Gardette, near Bourg d'Oisans: iron-grey, with calcareous amygdalites. 13.4 per cent of  $\text{CaO}$ ,  $\text{CO}_2$  with a little  $\text{MgO}$ ,  $\text{CO}_2$  was extracted by acetic acid. 7. Rock from the conjunction of the variolite with the limestone at the "Chapeau," Vallée des Dracs, Hautes Alpes. 8. Variolite from

Tour du Dourmant, near Fréjus: slaggy; the amygdalites destroyed. 9. Variolite from Senonges in the Vosges. 10. Melaphyre from Hemilla in the Tyrol (augite-porphry), containing 7.15 per cent of  $\text{CaO}$ ,  $\text{CO}_2$ . 11. Rock from the extinct volcano of Beaulieu, near Aix in Provence: impure dark green or yellowish, structure foliated. Occurring with other lavas, and referred by Gueymard to olivine.

It is to be understood that the following analyses only comprise the residues left after treatment with acetic acid. The analyses show, that the variolites present to us a mixture of different silicates, in part extremely complicated, and admitting indeed of no general formulæ. The comparatively low amount of silica is worthy of remark. None of the variolites are augitic.

|                               | 1.    | 2.    | 3.     | 4.     | 5.     | 6.     | 7.     | 8.    | 9.    | 10.    | 11.      |
|-------------------------------|-------|-------|--------|--------|--------|--------|--------|-------|-------|--------|----------|
| $\text{SiO}_2$ . . .          | 52.19 | 50.10 | 45.21  | 50.21  | 46.57  | 48.05  | 45.5   | 55.0  | 49.0  | 46.85  | 51.66    |
| $\text{Fe}_2\text{O}_3$ . . . | 5.64  | 9.94  | 7.65   | 11.64  | 19.57  | 22.51  | 25.0   | 12.0  | 14.5  | 16.73  | 24.33    |
| $\text{Al}_2\text{O}_3$ . . . | 20.89 | 18.41 | 14.95  | 16.40  | 14.68  | 10.97  | 15.0   | 25.0  | 14.5  | 16.10  | 10.34    |
| $\text{FeO}$ . . .            | 6.00  | 3.68  | 8.02   | 1.22   | —      | 2.60   | —      | 1.2   | —     | —      | —        |
| $\text{MgO}$ . . .            | 5.00  | 5.96  | 13.21  | 7.82   | 7.18   | 6.00   | 3.0    | 1.1   | 1.8   | 3.12   | 1.67     |
| $\text{MnO}$ . . .            | 0.39  | 0.73* | —      | —      | —      | —      | —      | —     | —     | —      | 0.34†    |
| $\text{CaO}$ . . .            | 0.60  | 0.36  | —      | —      | —      | —      | 2.5    | 2.5   | 0.8   | 9.15   | 6.66     |
| $\text{NaO}$ . . .            | 4.63  | 4.42  | 6.54†  | 5.21   | 8.0‡   | 4.57   | —      | —     | 10.4‡ | —      | —        |
| $\text{HO in ch. comb.}$      | 5.14  | 6.37  | 3.83   | 5.45   | 4.67   | 4.40   | 6.2    | 3.0   | 5.0   | 6.44   | 3.00     |
| $\text{HO hygroscopic}$       | —     | —     | 0.52   | 1.00   | 1.00   | 1.00   | 1.2    | —     | —     | 1.61   | 2.00     |
| Total . . .                   | 99.98 | 99.97 | 100.00 | 99.94§ | 100.00 | 100.00 | 100.0§ | 100.0 | 100.0 | 100.00 | 100.00** |

\* Sesquioxide.

† Determined as "difference," including loss.

‡ Idem.

§ Loss 1.6 per cent.

|| Including loss.

¶ Sesquioxide.

\*\* Loss 1.00 per cent.

**Kersantone (Micaceous Diorite).**—The French geologists designate by the name of Kersantone, a kind of micaceous diorite which occurs at the roadstead of Brest, forming thick veins or dykes in the granite and oldest slate rocks of that locality. It has been employed in the construction of most of the churches in Brittany; and is supposed to consist essentially of hornblende and mica, often mixed with a little feldspar and calcareous-spar(1). Delesse has now made an examination of this rock, and also of a similar variety, which he calls kersantite, from the Vosges(2).

1. Kersantite from Wisembach in the Vosges. This variety forms, at Wisembach, an irregular vein in granitic gneiss. It consists principally of about 70 per cent of oligoclase and 30 per cent of mica, but hornblende is also occasionally present. It is almost always of a highly crystalline character. In a vein, coarsely crystalline but in other respects identical with the substance of the surrounding rock, Delesse made out the following minerals: oligoclase of a whitish or greenish-white colour, becoming reddish or almost garnet-red by decomposition, see p. 492; quartz, small in quantity and not easily

(1) See Rivière in Bull. Géol. [2] I, 528; Dufrénoy in Expl. de la Carte Géol. de France, I, 1841, 198; Naumann's Geognosie, I, 580.

(2) Bull. Géol. [2] VII, 704.

Kersan-  
tone  
(Mica-  
ceous  
diorite)

detected; brownish-black mica (ferro-magnesian), rare, but more abundant in the rock; and dark or bright green fibrous hornblende. In certain gneiss-like patches, reddish-brown garnet also occurred. The occasional constituents comprise pyrites, copper-pyrites, galena, and magnetic pyrites. This variety of kersantite exhibits also, at times, amygdaloidal cavities, four inches and less in diameter, filled with quartz, chlorite, epidote, and calc-spar, succeeding each other with tolerable regularity from the outside to the inside, in the order here enumerated. Veins likewise occur in it of granular pegmatite, composed of quartz, orthoclase, black tourmaline, silver-white mica, and brownish-black mica. By ignition it loses 1.93 per cent. The loss is due principally to water, organic matter, and carbonic acid.

2. Kersantite from Sainte-Marie aux Mines. This variety forms a vein in a syenitic granite. It differs from the above by its structure, which is scarcely crystalline, and which sometimes is met with even more or less compact. Loss on ignition, 1.70 per cent.

3. Kersantone from Brest. This is very similar to the preceding. It frequently possesses a granitic structure with the before-mentioned whitish or greenish-white feldspar as its prevailing constituent. Commonly, however, the feldspar is compact, and of a uniform green or grey colour, appearing already to have suffered a certain alteration. It belongs to a trichonometric species, and exhibits the well-known twin striæ. The mica, a ferro-magnesian variety, is of a pinchbeck-brown, brownish-black, or pure black colour. Neither hornblende nor pyrite were detected by Delesse, though these minerals have been stated to occur in the rock by several geologists. A dark green carbonate of iron having some slight resemblance to hornblende, occurs in it however, together with white or pale-red calcareous-spar, the latter filling up the interstices of the feldspar, and also forming strings and veins. The kersantone, furthermore, sometimes contains very regular and even round cavities, in which amygdalites have formed. These, which are easily separable from the rock, are coated with very thin scales of mica, placed parallel to the surface of the amygdalite. Iron-pyrites also occurs in the mass of the kersantone, but more especially magnetic-pyrites, the presence of which may almost always be considered characteristic of these rocks. The other included minerals comprise magnetic-iron in microscopic grains; quartz (rarely present); and epidote in little veins of irregular thickness. The quartz, also, like the calc-spar, fills up the interstices of the feldspar crystals, which are sharply moulded in it; and it likewise occurs in the amygdalites. Besides the above, and especially in the cavities, a green, hydrated silicate of iron and magnesia (*chlorite ferrugineux*) is met with. The loss on ignition, principally due to carbonic acid, amounted to 4.49 per cent in a granitic kersantone with brown mica, green siderose, and white calc-spar from Daoulas; to 6.75 per cent in a greyish-green kersantone with large folia of

pinchbeck-brown mica, also from Daoulas, and which is employed as a building stone; and to 7.41 per cent in a greyish and light green granular kersantone with globular amygdalites of calc-spar and quartz. The analysis of a kersantone from Daoulas, commonly employed at Brest for building purposes, and which effervesced strongly in acids—showed the following composition:

Kersan-  
tone  
(Mica-  
ceous  
diomite)

| SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> , FeO, MgO, KO, NaO.* | Cl <sub>2</sub> O <sub>3</sub> † | CaO. | CO <sub>2</sub> , HO. | Total. |
|------------------|------------------------------------------------------|----------------------------------|------|-----------------------|--------|
| 52.80            | 35.05                                                | traces                           | 5.40 | 6.75                  | 100    |

\* Determined as "difference;" the FeO amounted to about 7 per cent.

† Contained in the mica.

**Serpentine.**—Delesse has also examined the serpentine of the Vosges(1). This contains the following minerals; partly disseminated through it, and partly in small veins: garnet (2) chromic-iron, magnetic-iron, pyrites, diallage, and chlorite. The chromic-iron is often enclosed in the substance of the garnet, sometimes irregularly scattered through it, and sometimes in concentric zones, either near the surface, or towards the centre of the mass. The iron-pyrites is also principally met with in the garnet lumps, but is rather rare. The diallage is occasionally disseminated through the body of the rock(3), but occurs more generally in large masses, or running into veins, which at their borders, pass gradually into the serpentine, and which consist of variously coloured and intermixed varieties, in the manner of the diallage and smaragdite of the euphotide of Corsica. The chlorite occurs in small veins, and in the inside of the garnet; in the latter case, manifestly as a pseudomorphous product derived from that mineral(4). If we take the analysis of the specimen from Narul as our basis, 100 parts of garnet lose in this transformation, 8.33 of silica, 5.06 of alumina, 3.89 of sesquioxide of iron, and 2.39 of lime; and make up their normal weight by the gain of 8.76 of magnesia, 8.63 of water, 1.39 of protoxide of manganese, and 1.14 of sesquioxide of chromium. According to some experiments by G. Bischof(5), a solution of bicarbonate of magnesia is decomposed by freshly-precipitated silicate of lime, even in the cold, into carbonate of lime and silicate of magnesia; on the authority of which he has sought to explain the pseudomorphous formation of chlorite from garnet, by the action of water containing carbonate of magnesia in solution. This is presumed to infiltrate through the serpentine, and decompose the silicate of lime in the garnet. Delesse believes that the transformation of garnet into chlorite—seen in all the serpentines of the Vosges—

• (1) Ann. Min. [4] XVIII, 309; Zeitschrift der Deutschen Geolog. Gesellsch. II, 427, Froriep's Berichte ub. d. Fortschritte d. Nat. u. Heilk. 1851, No. 294.

(2) See page 490.

(3) See page 486

(4) See page 508.

(5) G. Bischof's Lehrbuch der Chem. und Phys. Geologie II, 489



Serpentine.

has taken place in this manner. Besides the above, numerous veins occur in these serpentines, containing asbestiform chrysotile(1), noble serpentine, carbonate of lime, dolomite, and here and there, also, nemalite and brucite. The carbonate of lime contains from a few thousandths to 1.19 and 1.67 per cent of mechanically included water. Finally, specular-iron is likewise sparingly present; and in certain places, granite masses are imbedded in the serpentine.

The colours of the rock are very numerous, but green or chestnut-brown predominate; and these various tints intermix with one another in more or less regular divisions, so that a reticulated appearance often results. As the greenish-black and the chestnut-brown serpentines possess nearly the same composition, the different colours probably arise from the degree of oxydation of the iron, and from infiltrated matters which have entered along the fissures and vein-walls. But these infiltrations have not produced, as at the surface, any red coloration in the lower part of the rock, but rather a dark-green tint, indicating a process of reduction. The loss on ignition, consisting of water, some organic substances, and at times a little carbonic acid arising from carbonate of lime, amounted to:

|                                                                                                                                     |       |
|-------------------------------------------------------------------------------------------------------------------------------------|-------|
| In the serpentine of the Col de Pertuis, commune of Liésey . . . . .                                                                | 10.70 |
| In a green serpentine, inclining to chestnut-brown, with many disseminated garnets, from the Grotte des Fromages at Tholy . . . . . | 10.10 |
| In serpentine from Goujot . . . . .                                                                                                 | 9.42  |
| In brownish-red serpentine, with green particles and leaves of diallage, from Tendon . . . . .                                      | 8.49  |

The blackish-green basis (spec. grav. = 2.749) of the serpentine of the Col de Pertuis, yielded on analysis the following composition: silica 40.83 per cent, alumina 0.92, sesquioxide of chromium 0.68, protoxide of iron 7.39, protoxide of manganese traces, lime 1.50, magnesia (as difference) 37.98, loss on ignition 10.70. The mass was attacked by hydrochloric acid, with separation of granular silica; but complete decomposition did not take place, as only 0.75 per cent of lime was dissolved. The residue may be considered to consist of garnet. The chestnut-brown serpentine of Goujot yielded: silica 42.26 per cent, alumina (containing sesquioxide of chromium and sesquioxide of manganese) 1.51, protoxide of iron 7.11, lime 0.80, magnesia (as difference) 38.90, loss on ignition 9.42.

**Nepheline-Dolerite.**—Heidepriem(2) has examined the nepheline-dolerite of the Löbau Rocks, first described by Gumprecht(3). In its structure it varies from fine to coarse granular, and in the latter case, its essential constituents, nepheline and augite, may be distinctly recognized. Magnetic iron, olivine, and apatite, are subordinate ingredients. The powdered rock, levigated and then dried at

(1) See page 508.

(2) J. Pr. Chem. L, 500; Zeitschrift d. Deutschen Geolog. Gesellsch. II, 139.

(3) Pogg. Ann. XLII, 174.

100°, was treated with hot nitric acid, which dissolved the nepheline, olivine, and apatite completely, but only a slight amount of augite and magnetic iron (A). [A special examination of diopside, showed that the portion (11.23 per cent) decomposed by hot hydrochloric acid, contained very nearly the same relative proportions of the separate constituents, as the undecomposed portion; and it is Heidepriem's belief, that in the analysis of compound rocks we may always assume this to hold good for the augitic substances present in them]. The portion of the powdered dolerite insoluble in nitric acid, was treated with concentrated hydrochloric acid; this effected the solution of the magnetic iron, and the basic portion of the decomposed augite (B). The free silica was removed from the residue by carbonate of soda, and the remaining augite fused with the same reagent (C). The amounts of water and chlorine were determined directly. The presence of fluorine was proved qualitatively, but the amount of this substance present in the rock, was calculated from G. Rose's formula for apatite. (D) is the composition of the rock as a whole, deduced from these analyses; but a special analysis (E), in which decomposition was effected by means of hydrofluoric acid, was also undertaken for the same purpose. Heidepriem determined, furthermore, the composition of the nepheline of this rock(1).

|   | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | CaO   | MgO  | NaO  | KO   | PO <sub>5</sub> | CaCl | CaFl | Mn <sub>2</sub> O <sub>3</sub> | FeO   | MnO   | H <sub>2</sub> O | TiO <sub>2</sub> | Total. |
|---|------------------|--------------------------------|--------------------------------|-------|------|------|------|-----------------|------|------|--------------------------------|-------|-------|------------------|------------------|--------|
| A | 35.79            | 23.92                          | 7.91                           | 6.86  | 2.13 | 8.61 | 3.31 | 3.24            | 0.06 | 0.53 | trace                          | —     | —     | 6.73             | —                | 98.17  |
| B | 51.17            | 5.76                           | —                              | 18.65 | 8.78 | —    | —    | —               | —    | —    | —                              | 12.85 | trace | —                | —                | 97.25  |
| C | 50.37            | 5.89                           | —                              | 19.34 | 9.45 | —    | —    | —               | —    | —    | —                              | 13.39 | 0.17  | —                | —                | 98.61  |
| D | 41.13            | 14.33                          | 6.61                           | 12.23 | 5.33 | 4.38 | 1.70 | 1.65            | 0.01 | 0.27 | —                              | 20    | 0.06  | 3.42             | —                | 98.35  |
| E | 42.12            | 14.35                          | 13.12                          | 13.00 | 6.14 | 4.11 | 2.18 | 1.65*           | 0.04 | 0.27 | —                              | —     | 0.18  | 3.42*            | 0.54             | 101.12 |

\* Deduced from the first analysis. The same applies also to the amount of chlorine.

So far as it could be done, the relative proportions of the minerals present in this nepheline rock, were also determined. Viewed in this light, the rock consists of 45.38 per cent of augite, 32.61 of nepheline, 4.00 of magnetic iron, 3.91 of apatite, 3.12 of water, and 1.33 of rutile. The remaining 9.35 per cent belong partly to the olivine substance, soluble in nitric acid, and partly to another augitic portion of the rock, also decomposable by nitric acid, but which does not admit of a more definite determination. Heidepriem leaves it undecided as to which of these constituents the water found in the rock belongs.

**Trachyte.**—Ebelmen(2) has analyzed, at the request of Ch. Martin's, an eruptive rock (A) from the coal formation of Commeny (Allier). The bituminous coal has been converted in the vicinity of this trachyte, into prismatic coke, the prisms of which are placed at

(1) See page 490.

(2) Compt. Rend. XXXI, 656; Instit. 1850, 354.

**Trachyte.** right angles to the surface of the rock. The trachyte is white and granular, and forms in water a paste which, after drying, becomes extremely hard. Martins has compared it with the domite of the Puy-de-Dôme, according to J. Girardin's analysis of the latter (B) :

|   | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | CaO  | MgO  | KO   | NaO  | Cr <sub>2</sub> O <sub>3</sub> | Mn <sub>2</sub> O <sub>3</sub> | HO   | Loss | Total  |
|---|------------------|--------------------------------|--------------------------------|------|------|------|------|--------------------------------|--------------------------------|------|------|--------|
| A | 59.52            | 22.08                          | 2.24                           | 2.31 | 1.19 | 6.63 | 0.66 | 0.66                           | —                              | 5.50 | —    | 100.40 |
| B | 51.00            | 24.00                          | 8.34                           | 2.06 | 7.82 | 1.66 | —    | —                              | 0.64                           | —    | 1.48 | 100.00 |

**Alum-Rock.**—F. Fridau(1) has examined an alum-rock, originating, in his opinion, from the action of solfataras and siliceous springs on the Gleichenberg trachytes of Styria, and apparently forming veins or beds in these. It possesses a light yellowish-grey colour; and many varieties resemble porcelain or semi-opal. It is brittle, and harder than feldspar. The spec. grav. of a compact variety equalled 2.371 at 23° C. Separate, sharp-edged portions, with their interstices filled up with amorphous silica, may be perceived, even on apparently homogeneous surfaces. The substance, dried in the air, gave the following composition :

| SiO <sub>2</sub> | SO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO   | MgO   | KO    | HO    | KO.SiO <sub>3</sub> | MgO.SO <sub>3</sub> | Mg Cl | Total   |
|------------------|-----------------|--------------------------------|--------------------------------|-------|-------|-------|-------|---------------------|---------------------|-------|---------|
| 50.711           | 16.505          | 1.130                          | 19.063                         | 0.558 | 0.407 | 3.974 | 7.231 | 0.307               | 0.088               | 0.033 | 100.007 |

Fridau believes, that, in another point of view, this alum-rock consists of: salts soluble in water 0.428 per cent, alum-stone (alunite) 37.758, silica and silica-compounds 54.590, and water 7.231.

A clayey rock, occurring in the vicinity of the above, was composed as follows :

| SiO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | MgO   | CaO   | HO    | Total  |
|------------------|--------------------------------|--------------------------------|-------|-------|-------|--------|
| 89.302           | 1.834                          | 3.110                          | 0.127 | 0.137 | 2.319 | 99.829 |

**Lavas.**—Damour(2) has analyzed several volcanic rocks from Iceland. 1. A massive, sponge-like, and slaggy lava from the foot of Hecla(3). This, which formed part of a lava current of 1845, is still very thick and massive at some distance from the point of eruption. In places there occurs in it a white, glassy, feldspathic substance, easily attacked by acids, and possessing all the characters of anorthite. The lava itself scratches glass strongly, and attracts the magnetic needle. Its spec. grav. at 18°=2.833. On ignition it does not lose more than 0.07 per cent. It contains 33.25 per cent of matters soluble in acids(a), and 61.92 per cent of insoluble substances(b). 2. Trap from the Eskifjord. A massive black rock, as easily cleavable as clay-slate. It scratches glass, and is attracted by the magnet. Spec. grav. at 14°=2.638. On ignition, it yields

(1) Ann. Ch. Pharm. LXXVI, 106.

(2) Bull. Géol. [2] VII, 83.

(3) Already analyzed by Genth, see Annual Report for 1847 and 1848, II, 497.

water. The portion soluble in acids(*a*)=25·39 per cent, and the insoluble portion (*b*), 74·13

Lavas.

|     | SiO <sub>3</sub> | TiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | Fe <sub>2</sub> O <sub>3</sub> | CaO  | MgO. | NaO. | KO.  | HO.  | Total. |
|-----|------------------|------------------|--------------------------------|--------------------------------|------|------|------|------|------|--------|
| 1a  | 16 61            | 1 24             | 0 16                           | 10 08                          | 2 44 | 1·21 | 0·99 | 0·45 | 0·07 | 98·17  |
| b.  | 38 15            | 0 48             | 13 45                          | 5 53                           | 3 99 | 0·14 | 2·42 | 0·76 |      |        |
| 2a. | 13 18            | 0 80             | —                              | 8 19                           | 0 63 | 0·45 | —    | 0·75 | 1·09 | 99·52  |
| b.  | 51 10            | —                | 12 25                          | 2 91                           | 2 56 | —    | 4·76 | 0·52 |      |        |

In regard to the following minerals, also analyzed by Damour—viz.: Anorthite from the Thjorsa lava [Genth's Thjorsanite(1)]; labradorite from a decomposed basalt at Berufjord; and albite from a phonolite at the Laugafall in the neighbourhood of the Great Geyser.—See pp. 494 and 491.

**Pumice.**—Ehrenberg(2) has examined the white earthy substance which occurs in a hill between Puteoli and Naples (*collis leucogæus*), and which, when mixed with spelt, was eaten by the Romans as a kind of thick broth (*allica*). It consists of a mixture of pumice-dust with phytolitharia and the shells of polygastrica; all belonging to well-known fresh-water.

According to Ehrenberg, a distinction is to be made between the different kinds of pumice. Certain glassy and froth-like rock-matters for instance, resembling ordinary pumice in external characters, and which have hitherto been called pumice by all observers, contain organic remains in a semi-fused condition, or more or less altered by fire; whilst other varieties, associated with obsidian, exhibit none of these organisms. The latter occur in vast masses in the Lipari Isles; whilst certain pumice-rocks of the Eifel, the Kammerbühl, the volcano of Maipo near St. Jago in Chili, &c., belong to the former group. Ehrenberg would separate these entirely from common pumice, under the name of *volcanic froth-stones*. He does not look upon the organic matters as subsequent additions to the rock, but considers these froth-stones to have been originally mixed with tertiary organic substances and to have been ejected in a pulverized or dust-like condition. It is however, true, that organic matters from meteoric dust, &c., might occur at the surface of these rocks—but only at the surface: as the pores would soon get filled up; and such organic particles even by the aid of the moisture in the rock, would not be able to penetrate, at the utmost, more than half an inch into the substance of the pumice.

**Volcanic Ashes.**—Ehrenberg(3) has also investigated the fresh ashes ejected from Vesuvius on the 9th of February, 1850. These are black, and in small grains, like tolerably fine gunpowder. The microscope shows no fused globules, but broken, irregular particles.

(1) Annual Report for 1847 and 1848, II, 407.

(2) Berl. Acad. Ber. 1850, 351; Instit. 1851, 167.

(3) Berl. Acad. Ber. 1850, 78; Arch. Ph. Nat. XV, 79; Instit. 1850, 255; see page 530.

Volcanic  
ashes.

The finest of these are glassy and transparent, but not crystalline. Amongst them a few separate hairs and fibres of plants are scattered. One part of the ashes is singly-refracting and colourless; another part, doubly-refracting and vividly coloured. The first has evidently originated in the interior of the crater, but the latter may have been derived from various kinds of rock. The vegetable matters may have proceeded from ordinary atmospheric dust, or from the surface of the surrounding rocks, or from ancient peat masses. A few particles are micaceous. Not any of the organic substances are marine.

According to an analysis performed in the laboratory of H. Rose, the dust from these ashes yields magnetic iron to the loadstone, and contains silica and the protoxide and sesquioxide of iron as predominating ingredients, together with lime, magnesia, and alumina. The dust is evidently of an augitic nature. Phosphoric acid, also, was detected in it.

**Stratified Rocks. Ice.**—H. Schlagintweit(1) has carried out an interesting series of observations on the structure of glacier ice, and on that of ice in general; as well as on the connection of this structure with the movement of glaciers, and on the other phenomena appertaining to the subject. For particulars, however, we must refer to the original publication.

**Dolomite.**—R. Wildenstein(2) has analyzed a dolomite from the Muschelkalk beds near Saarbrücken. It consisted of:

| CaO, CO <sub>2</sub> . | MgO, CO <sub>2</sub> . | FeO, CO <sub>2</sub> . | Clay and quartz. | KO.   | Total. |
|------------------------|------------------------|------------------------|------------------|-------|--------|
| 54.47                  | 41.62                  | 1.88                   | 1.88             | trace | 99.85  |

C. Karsten(3) has analyzed an asphalt rock, or dolomite containing asphaltum, from the Island of Brazza, and from several other localities in Dalmatia. This rock forms a stratum 12 feet thick, in the Upper Jurassic beds. The specimens from Brazza are brown, and slightly shining on the fresh fracture. They exhibit, also, a great number of small pores and cavities, part of which are lined with delicate rhombohedral crystals, whilst others are filled with pure asphaltum. The analysis yielded: asphaltum (asphaltene and petroleum) 7.12 per cent, carbonate of protoxide of iron 1.10, besides the chlorides of sodium and potassium.

G. Leube(4) has analyzed a great number of dolomites. For the localities and composition of these, see Table F.

**Millipore-Limestones.**—Damour(5) has examined several millipore-limestones of modern origin, employed in France as an hydraulic cement, and forming important deposits in various localities.

(1) Untersuchungen über die Physikalische Geographie der Alpen; Pogg. Ann. LXXX, 177 (in abstr.)

(2) J. Pr. Chem. XLIX, 154.

(4) Jahrb. Pharm. XX, 139.

(3) Jahrb. Miner. 1850, 60.

(5) Bull. Géol. [2] VII, 675.

# ANALYSES OF DOLOMITES.

[TO FACE PAGE 560.]

(F.)

|                       | 1.    | 2.    | 3 <sup>a</sup> . | 3 <sup>b</sup> . | 4 <sup>a</sup> . | 4 <sup>b</sup> . | 4 <sup>c</sup> . | 5.     | 6.    | 7.    | 8.    | 9.    | 10.   | 11.    | 12.   | 13.   |
|-----------------------|-------|-------|------------------|------------------|------------------|------------------|------------------|--------|-------|-------|-------|-------|-------|--------|-------|-------|
| Spec. grav.           | 2.777 | 2.793 | 2.770            | 2.770            | 2.703            | 2.776            | 2.754            | 2.755  | 2.779 | 2.777 | —     | 2.822 | 2.833 | 2.881  | 2.887 | 2.857 |
| Carbonate of magnesia | 44.98 | 44.10 | 42.631           | 44.88            | 38.302           | 42.440           | 44.04            | 44.178 | 41.97 | 43.69 | 36.62 | 45.24 | 45.24 | 46.50  | 46.27 | 45.06 |
| Carbonate of lime     | 54.18 | 54.75 | 55.837           | 53.88            | 61.637           | 57.070           | 55.83            | 54.910 | 53.27 | 54.40 | 45.25 | 54.37 | 51.67 | 53.50  | 53.72 | 53.71 |
| Total                 | 98.96 | 98.85 | 98.518           | 98.76            | 99.939           | 99.510           | 99.87            | 99.088 | 95.24 | 98.09 | 81.87 | 99.61 | 98.81 | 100.00 | 99.99 | 98.77 |

|                       | 14.   | 15.   | 16.   | 17.   | 18.   | 19.   | 20.   | 21.   | 22.   | 23.   | 24.   | 25.   | 26.   | 27.   | 28.   |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Spec. grav.           | 2.785 | 2.844 | 2.758 | 2.732 | 2.732 | 2.844 | 2.732 | 2.739 | 2.769 | 2.739 | 2.785 | 2.778 | 2.763 | 2.763 | 2.786 |
| Carbonate of magnesia | 28.72 | 42.04 | 29.93 | 36.95 | 38.25 | 41.28 | 43.35 | 32.30 | 20.85 | 34.58 | 37.54 | 39.49 | 43.87 | 65.84 | 39.28 |
| Carbonate of lime     | 38.21 | 57.04 | 54.44 | 48.98 | 46.73 | 57.26 | 50.57 | 56.39 | 42.01 | 62.76 | 61.21 | 60.24 | 54.88 | 54.13 | 56.40 |
| Total                 | 66.93 | 99.08 | 84.37 | 85.93 | 84.98 | 98.54 | 93.92 | 88.69 | 62.86 | 97.34 | 98.75 | 99.73 | 98.75 | 99.97 | 95.68 |

|                       | 29.   | 30.   | 31.   | 32.   | 33.   | 34.   | 35.   | 36.   | 37.   | 38.   | 39.   | 40.   | 41.   | 42.   | 43.   |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Spec. grav.           | 2.773 | 2.777 | 2.754 | 2.784 | 2.736 | 2.766 | 2.777 | 2.777 | 2.652 | 2.439 | 2.518 | 2.564 | 2.518 | 2.645 | 2.550 |
| Carbonate of magnesia | 41.39 | 38.08 | 34.57 | 34.65 | 42.50 | 45.29 | 38.23 | 40.77 | 21.98 | 28.22 | 36.12 | 29.19 | 44.94 | 42.00 | 42.84 |
| Carbonate of lime     | 56.75 | 61.63 | 61.38 | 57.99 | 57.39 | 56.24 | 58.29 | 58.77 | 77.93 | 70.28 | 56.12 | 58.45 | 53.94 | 52.64 | 58.66 |
| Total                 | 98.14 | 99.71 | 95.90 | 92.64 | 99.89 | 99.50 | 91.52 | 99.54 | 99.91 | 98.50 | 92.14 | 87.64 | 98.83 | 94.64 | 98.50 |

From the Azalic and Older Paleozoic Transition rocks: 1. From the Aschensee. 2. From the Yassa valley. 3. From the Salaria brook, Grödnertal. 4. From the so-called Hauptwerk of St. Agatha, between Redarze and Trient. 5. From the Schlierkofel in the Tyrol. 6. From the Brenner in the Tyrol. 7. From Colfosco. 8. From the ancient limestone of the Vesp valley in the Valais. 9. From Gerolstein. 10. From Dietz. 11. From the Zechstein, &c.: 11 to 13. From Heidelberg. 14. From the Nieder-Rodenbach. 15. From Rükingen, near Hana. 16. From Eisleben (Kauchwacke). 17. From Berneck, not far from Freudenstadt. 18. From Nagold. 19. From the Triassic rocks (the Muschelkalk): 19. From Hofenheim in Baden. 20. From Sulz. 21. From Birkenfeld, near Neuenburg. 22. From Nagold. 23. From the Jurassic rocks: 23. From Kolbingen, Suabian Alp. 24. From Alt-Stenslingen, Suabian Alp. 25. From Lauterach, Suabian Alp. 26. From Ehingen, Suabian Alp. 27. From Franconia. 28. From Theuringshofen, Suabian Alp. 29. From Macholsheim, Suabian Alp. 30. From Lauterne Suabian Alp. 31. From Streiberg in Franconia. 32. From the fortress of Ingolstadt. 33. From Gerhausen in the Blaulth, Suabian Alp. 34. From Allmendingen, Suabian Alp. 35. Dolomite from the basaltic tufa of the Kalwerbühl near Bettingen, in the Ermenthal. 36. From Sternenberg, Suabian Alp. 37. From Rükenstich, near Blaubeuren. 38. From tertiary freshwater limestone: 38. to 43. From Dachingen, Suabian Alp. In fourteen other dolomites, many of which belonged to the keuper or red-marl (Upper Triassic) series, the spec. grav. was under 2.7, and the whole amount of carbonate of magnesia below 4 per cent, except in a specimen from Würzburg, in which the latter reached 7 per cent. Leube considers that these should not be looked upon as true dolomites, from which they may generally be distinguished by their specific gravity. He does not, however, determine in this respect any definite limits.

# ANALYSES OF LIMESTONES.

[TO FACE PAGE 561.]

(G.)

|                       | 1a.    | 1b.    | 2a.   | 2b.    | 3.    | 4.    | 5a.    | 5b.    | 6a.      | 6b.      | 6c.      | 7.      | 8a.    | 8b.    | 9a.    | 9b.    | 10a.   | 10b.   |
|-----------------------|--------|--------|-------|--------|-------|-------|--------|--------|----------|----------|----------|---------|--------|--------|--------|--------|--------|--------|
| Carbonate of lime     | 57.10  | 52.64  | 1.920 | 50.40  | 86.00 | 80.50 | 88.00  | 88.40  | 84.40    | 83.60    | 82.00    | 85.60   | 85.40  | 92.80  | 92.20  | 90.50  | 91.80  | 90.04  |
| Carbonate of magnesia | 40.28  | 39.00  | 37.30 | 39.00  | 3.37  | 3.70  | 3.00   | 5.10   | 5.28     | 5.88     | 5.34     | 4.33    | 3.30   | 3.20   | 2.90   | 3.20   | 4.10   | 4.96   |
| Alumina               | 2.12†  | 7.20   | 5.60  | 3.50*  | 7.82* | 1.60* | 2.20*  | 3.00*  | 3.60*    | 2.00*    | 3.60*    | 8.17*   | trace* | 3.20   | 2.50   | 3.20   | 3.20   | 4.00   |
| Insoluble clay        | 2.43   | 1.20   | 7.80  | 8.00   | 6.59  | 5.00  | 4.80   | 3.60   | 14.00    | 16.00    | 14.40    | 6.20    | 2.00   | 2.00   | 2.40   | 4.00   | 0.80   | 1.10   |
| Total                 | 99.38  | 100.00 | 99.90 | 100.90 | 99.78 | 99.80 | 100.00 | 100.10 | 107.85** | 107.48** | 105.34** | 99.80   | 100.70 | 100.98 | 100.00 | 100.80 | 99.90  | 100.00 |
| Carbonate of lime     | 81.60  | 80.00  | 90.40 | 90.40  | 95.00 | 95.00 | 94.00  | 97.35  | 97.00    | 94.00    | 96.80    | 86.70   | 94.40  | 94.40  | 94.00  | 60.40  | 56.60  | 57.60  |
| Carbonate of magnesia | 3.90   | 3.20   | 4.14  | 3.56   | 2.40  | 2.27  | 2.77   | 2.20   | 2.86     | 2.42     | 2.80     | 39.20   | 2.18   | 2.00   | 2.00   | 36.80  | 37.21  | 1.90   |
| Alumina               | 6.40*  | 7.20*  | 1.80* | 2.30   | 1.66  | 1.66  | 3.00*  | trace  | trace    | 1.20     | 4.00     | 2.00    | 4.00   | 1.60   | 4.00   | 3.60   | 2.60   | 6.80   |
| Insoluble clay        | 10.80  | 14.00  | 2.80  | 3.00   | —     | —     | —      | —      | 0.80     | —        | —        | —       | —      | 2.40   | —      | —      | —      | 4.00   |
| Total                 | 101.80 | 104.40 | 99.14 | 99.56  | 99.06 | 98.93 | 99.83  | 99.65  | 99.86    | 99.22    | 100.90   | 100.60* | 99.50  | 100.58 | 100.40 | 100.00 | 98.41  | 100.30 |
| Carbonate of lime     | 89.00  | 90.60  | 91.20 | 92.40  | 91.40 | 94.00 | 79.00  | 88.00  | 94.80    | 92.20    | 89.60    | 79.20   | 76.00  | 59.20  | 66.00  | 64.00  | 66.60  | 66.60  |
| Carbonate of magnesia | 2.07   | 2.07   | 2.07  | 2.11   | 2.11  | 2.17  | 1.73   | 1.80   | 1.17     | 1.82     | 1.49     | 1.45    | 1.49   | 1.17   | 1.44   | 1.40   | 1.78   | 1.78   |
| Alumina               | 3.20   | 3.00   | 3.00  | 2.40   | 2.80  | 1.20  | 2.00   | 4.00   | 3.00     | 3.00     | 3.00     | 3.20    | 2.00   | 6.40   | 1.60   | 2.40   | 1.60   | 1.60   |
| Insoluble clay        | 5.60   | 3.40   | 1.80  | 2.40   | 2.80  | 2.00  | 15.20  | 6.28   | 2.00     | 4.00     | 4.00     | 15.00   | 16.20  | 41.60  | 30.00  | 32.00  | 30.80  | 30.80  |
| Total                 | 99.87  | 98.07  | 98.07 | 99.31  | 99.11 | 99.37 | 98.83  | 100.08 | 100.37   | 99.32    | 100.09   | 100.82  | 104.82 | 100.65 | 103.57 | 99.84  | 100.30 | 100.38 |

† White.—\* Brownish-red ferruginous.—\*\* The excess arises from the presence of  $N_2O$  (as silicate), which becomes transformed, during the drying of the specimen, into  $MnO$ ,  $Mn_2O_3$ .

1. Lower magnesian limestone (unterer Zechstein) from the road to the Höttinger Alp, near Innsbruck, dark ash-grey. 2. From Kahl on the Spessart. 3. From Annaberg in Lower Austria. 4. Containing tonnelite, from Muthmannsdorf in Lower Austria (Stüdtstein). 5. From Grottobach, near Allend, in Lower Austria (graves of sulphurated hydrogen during softening). 6. From Rank in Lower Austria. 7. From Epian in the Tyrol. 8. From Rudolfsbad in Thuringia. 9. From Ilmenau (Stinkstein). 10. From Paternon in Carinthia. 11. From the Seiser Alp, Tyrol. 12. Black compact limestone from St. Triphan, between Algé and Bex, in Switzerland (Escher's "Hohegebirgskalk" considered by Stüdt to belong to the Lias). 13. Compact fine-grained limestone from the Raos Moos-Alm, near Ischl. 14. From Steinbrunn in Lower Austria. 15. From the Castle-Rock at Stanz, in Lower Austria. 16. An ash-grey variety from the Höttinger Alp, near Innsbruck. 17. A yellowish-white variety from the Rumer Joch, near Innsbruck. 18. From the island of Lessing, Dalmatia. 19. From the hoher Kundl Rock, near Teils, in the Tyrol. 20. From Predazzo, in the Tyrol. 21. Dom Tyrol, near Rome. 22. From the Chumis, above Wessenberg, in Switzerland. 23. From the Unterberg, near Salzburg. 24. From the Brudeberg, near Nicksburg, in Moravia. 25. From the summit of the Great Oetscher, in Lower Austria. 26. Chalk from the King's Tomb, near Thebes. 27. Chalk from Gravesend, in Kent. 28. From the island of Rugen. 29. From Meudon, near Paris. 30. From the island of Heligoland. 31. From Lonsberg, near Aix-la-Chapelle. 32. From Leves, near Brighton. 33. Granular limestone from Auebach. 34. From Algen in the Gastein valley. 35. From the Hiesberg, near Melk, in Lower Austria. 36. From the lower beds near Ködäch, in Styria. 37. From Braun am Walde, in the district "ob dem Manhartberge". 38. Niesen limestone, from the lower black limestone strata of the Niesen Chain. 39. Limestone from the Wymis Bridge. 40. Mountain limestone from Fromme, in Saxony. 41. Bluish-grey lias limestone from Stuttgart. 42. Spargangus-limestone from the western Swiss Alps.

This examination has led him to the conclusion that not only the polyyps but also the plants possess the power of decomposing the soluble lime- and magnesia-salts of the sea-water, and of receiving these salts as carbonates into their organic tissues; and that the origin of many magnesian limestones may be thus explained. Two specimens were subjected to analysis. The first (A) from Bréhat, Côtes-du-Nord, had the form of coral branches, and was of a light grey colour; but it was much worn by attrition, and had become all but fossil. It appeared to belong to *Millepora cervicornis*. The second specimen (B) from the Mediterranean, had also a stony aspect and compact fracture, with almost the hardness of limestone; its structure was made up of curvilinear folia crossing each other in all directions. It belonged to a species of spongiæ.

| Organic Quartz-sand |                        |                        |      |      |                                  |                   |                   |         |         |                   |        |
|---------------------|------------------------|------------------------|------|------|----------------------------------|-------------------|-------------------|---------|---------|-------------------|--------|
|                     | CaO, CO <sub>2</sub> . | MgO, CO <sub>2</sub> . | NaO. | KO.  | Fe <sub>2</sub> O <sub>3</sub> . | SO <sub>3</sub> . | PO <sub>5</sub> . | mattér. | grains. | H <sub>2</sub> O. | Total. |
| A.                  | 87.32                  | 8.51                   | 0.45 | 0.34 | 0.55                             | 0.89              | 0.23              | 0.35    | 0.63    | 0.64              | 99.91  |
| B.                  | 77.36                  | 11.32                  | 0.55 | 0.27 | 0.08                             | 0.95              | 0.32              | 4.70    | 1.36    | 1.46              | 98.37  |

All the inorganic constituents dissolve in weak acids; and there remains only a spongiiform and very light organic structure, retaining the original form of the specimen. This possesses the peculiar garlic-like smell of decomposing algæ(1).

The calcareous sand from the coast of Brittany—which, as a manure and cement, has given rise to a considerable commerce—has been found by Horlin(2) to be of two distinct kinds: one sort consisting of the comminuted fragments of shells, and the other of those of corals (madrepores). The first produces a “fat,” and the second an “hydraulic,” lime.

We may also add here, an analysis by Silliman, Jun.(3), of the ashes of the horny stem of *Gorgonia antipathes* from Bermuda. These ashes amounted to about 6 per cent.

| Cl.  | Br.  | I.   | PO <sub>5</sub> . | SO <sub>3</sub> . | CO <sub>2</sub> . | SiO <sub>3</sub> . | K.  | Na.  | Mg. | CaO. | Sand & Carbon. | Total. |
|------|------|------|-------------------|-------------------|-------------------|--------------------|-----|------|-----|------|----------------|--------|
| 14.0 | 35.0 | 13.0 | 0.3               | 3.0               | 0.3               | 0.5                | 1.6 | 19.0 | 2.0 | 4.5  | 3.6            | 96.8   |

**Limestone.**—Ch. Grimm(4) has analyzed the grey marble of Villmar in Nassau. The percentage of iron, manganese, alumina, and silica, varies somewhat in different specimens. The specimen analyzed, belonged to one of the richest marbles in these constituents. 100 parts dried in the air, contained:

(1) See the investigations of Forchhammer in Annual Report for 1849, III, 575.

(2) Compt. Rend. XXX, 354.

(3) Proceedings of the 2nd Meeting of the American Association, 130.

(4) Jahrbuch d. Vereins f. Naturkunde im Herzogth. Nassau, 1850, 6 Heft, 140.



Limestone.

| CaO.  | MgO. | Fe <sub>2</sub> O <sub>3</sub> , Mn <sub>2</sub> O <sub>3</sub> , Al <sub>2</sub> O <sub>3</sub> . | CO <sub>2</sub> . | SiO <sub>2</sub> , clay, trace of carbon. | HO.  | KO and loss. |
|-------|------|----------------------------------------------------------------------------------------------------|-------------------|-------------------------------------------|------|--------------|
| 55.30 | 0.79 | 1.38                                                                                               | 43.04             | 0.90                                      | 0.35 | 0.24         |

The manganese and part of the iron are combined as protoxides with carbonic acid.

Holger(1) has analyzed a great number of limestones. The localities of these, and the results of the analyses, are given in Table G.

**Chalk.**—E. Maumené(2) has found that magnesia is not present in the brooks and wells at Rheims, nor in the chalk and peat of that neighbourhood. Two analyses of chalk, deducting the amount of water, gave the following results :

|    | CaO, CO <sub>2</sub> . | CaO, PO <sub>5</sub> . | Clay. | Fe <sub>2</sub> O <sub>3</sub> . | Total.  |
|----|------------------------|------------------------|-------|----------------------------------|---------|
| 1. | 96.684.                | 0.011                  | 2.670 | 0.535                            | 100.000 |
| 2. | 96.282                 | 0.078                  | 3.133 | 0.507                            | 100.000 |

**Green Sand.**—According to Von der Marck(3), the green sand of the Hamm district, has the following composition :

| SiO <sub>2</sub> . | FeO.  | Al <sub>2</sub> O <sub>3</sub> . | MgO. | KO.  | HO.  | PO <sub>5</sub> and trace |
|--------------------|-------|----------------------------------|------|------|------|---------------------------|
| 58.17              | 18.75 | 10.09                            | 2.37 | 3.37 | 6.25 | trace                     |

II. Wurtz(4) has proposed to employ the green sand of New Jersey for the preparation of alum and potassa(5). In like manner the green sand of Saxony has already been recommended by Geinitz and others as a manure(6). Many specimens of this American green sand consist almost entirely of glauconite; other specimens contain variable quantities of a red or brown earth, and also of quartz. Some, again, contain more or less carbonate of lime in such a condition, that it is not affected in the cold by diluted acids. In many specimens, also, iron-pyrites is present; and sulphate of iron in a few. Wurtz did not meet with phosphoric acid. The glauconite grains, besides potassa, silica, alumina, protoxide or sesquioxide of iron, and water—contain also, at times, a little magnesia. Two analyses of the entire mass of the green sand (called marl) from Shrewsbury, Monmouth County, gave the following results :

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> (also FeO). | KO, MgO.  | HO (hygrosc.) | HO. (in chem. comb.) | Total. |
|--------------------|-----------------------------------------------------------------------------|-----------|---------------|----------------------|--------|
| 48.24              | 32.89                                                                       | 6.38 2.60 | 4.81          | 5.69                 | 100.61 |
| 47.83              | 34.98                                                                       | 4.94 —    | 11.50         |                      | 99.25  |

(1) Elemente der Geognosie, Wien, 1850.

(2) Compt. Rend. XXXI, 270; see page 425 of this Report.

(3) Arch. Pharm. [2] LXIV, 173, from the Verhandl. d. Naturh. Vereins d. Preuss. Rheinlande, 1849, Part VI, 269.

(4) Sill. Am. J. [2] X, 326.

(5) See page 434.

(6) See Annual Report for 1849, III, 586.

W. Fisher(1) has also analyzed the green sand of New Jersey, from a locality a few miles south-east of Philadelphia. The rock is here bluish-green; soft and adhesive in the damp state, and in large and hard granular concretions when dry. It contains a slight admixture of quartz-sand. Phosphoric acid was tested for, but without success. The analysis yielded:

Green  
sand.

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | FeO.  | MgO. | CaO. | NaO. | KO.  | H <sub>2</sub> O. | Total. |
|--------------------|----------------------------------|-------|------|------|------|------|-------------------|--------|
| 53.26              | 3.85                             | 24.15 | 1.10 | 1.73 | 1.60 | 5.36 | 10.12             | 101.12 |

**Rocks of the Coal Measures.**—H. Taylor(2) has communicated to the British Association for the Advancement of Science, the results of a series of analyses performed by him on the rocks of the coal measures. The specimens were taken from the Hartley Pit, and may be considered typical of the strata of the coal formation. Each layer of coal forms the centre of a certain group of strata, the members of which, with very slight deviations, recur in all the other beds. This series, commencing with the uppermost rock, is in general as follows: Fire-clay or till, sandstone, blue shale, bituminous shale, coarse coal, or sometimes cannel coal, good coal, coarse coal, fire-clay. Sandstone is sometimes in contact with the coal, and occasionally the latter is associated with other stratified matters, as clay-ironstone; sometimes, also, several terms are wanting in the series, but these cases are exceptional. The specimens analyzed were taken, as far as possible, from one and the same group; and the actual succession of these, in an ascending order, with the thickness of each stratum in feet and inches, was as follows: 1. Fire-clay or till, 2 feet; coarse coal, 7 inches. 2. Good coal, 5 feet 2 inches. 3. Coarse coal, 3 inches. 4. Bituminous shale, 2 inches. 5. Blue shale, 3 feet 1 inch. 6. Micaceous sandstone, 7 inches; blue shale, 10 inches; micaceous sandstone, 7 inches; blue shale with ironstone nodules, 2 feet 1 inch; bituminous shale and coal, 6 inches; ironstone with shells, 1 foot 11 inches. 7. Muscle-bind, 6 inches. The numbers, 1 to 7, annexed to each of the foregoing divisions, correspond with those in the following table of analyses:

(1) Sill. Am. J. [2] IX, 83.

(2) Edinb. New Phil. Journ. L, P40.

Rocks of  
the coal  
measures.

|                                | 1.    | 2.     | 2 <sup>a</sup> . | 3.     | 3 <sup>b</sup> .  | 3 <sup>c</sup> . | 4.                | 5.                | 6.    | 7 <sup>g</sup> .   | 7 <sup>i</sup> . | 8.     |
|--------------------------------|-------|--------|------------------|--------|-------------------|------------------|-------------------|-------------------|-------|--------------------|------------------|--------|
| HO (chem. comb.)               | 10.52 | —      | —                | —      | —                 | —                | —                 | 11.08             | 6.89  | 11.22 <sup>h</sup> | —                | —      |
| CaO                            | 0.67  | —      | 8.92             | —      | 1.29              | trace            | 1.03              | 0.59              | 1.11  | 4.08               | 0.99             | —      |
| MgO                            | 0.75  | —      | 1.01             | —      | 0.42              | 0.66             | 0.52              | 1.38              | 0.32  | 1.08               | 0.29             | —      |
| Fe <sub>2</sub> O <sub>3</sub> | 2.01  | —      | 14.24            | —      | 2.19 <sup>d</sup> | traced           | 4.27 <sup>e</sup> | 4.57 <sup>f</sup> | 9.54  | 18.64 <sup>i</sup> | trace            | —      |
| Al <sub>2</sub> O <sub>3</sub> | 27.75 | —      | 10.88            | —      | 21.23             | 6.53             | 19.25             | 23.29             | 8.13  | 1.19               | —                | —      |
| KO                             | 2.19  | —      | 1.04             | —      | 2.20              | —                | 0.84              | 2.09              | 1.65  | 1.32               | 16.29            | —      |
| NaO                            | —     | —      | —                | —      | trace             | —                | 0.37              | —                 | 1.86  | —                  | —                | —      |
| NaCl and NaO, SO <sub>3</sub>  | 0.44  | —      | —                | —      | —                 | —                | —                 | trace             | —     | trace              | —                | —      |
| SiO <sub>2</sub>               | 55.50 | —      | 53.15            | —      | 1.12              | 60.81            | 34.28             | 52.45             | 70.26 | trace              | —                | —      |
| C                              | —     | 78.69  | —                | 70.31  | —                 | —                | 26.7 <sup>j</sup> | —                 | —     | 14.06 <sup>k</sup> | 31.07            | 78.06  |
| H                              | —     | 6.00   | —                | 4.71   | —                 | —                | 2.63              | —                 | —     | —                  | —                | 5.81   |
| N                              | —     | 2.37   | —                | 1.46   | —                 | —                | 0.93              | —                 | —     | —                  | —                | 1.85   |
| O                              | —     | 10.67  | —                | 5.43   | —                 | —                | 9.09              | —                 | —     | —                  | —                | 3.12   |
| S                              | —     | 1.51   | —                | 1.21   | —                 | —                | —                 | —                 | —     | —                  | —                | 2.22   |
| Ashes                          | —     | 1.36   | —                | 16.86  | —                 | —                | —                 | —                 | —     | —                  | —                | 8.94   |
| Cl                             | —     | —      | trace            | —      | —                 | —                | trace             | —                 | —     | —                  | —                | —      |
| SO <sub>3</sub>                | —     | —      | 8.21             | —      | 1.70              | —                | —                 | trace             | —     | —                  | —                | —      |
| Unconsumed coal                | —     | —      | 26.57            | —      | —                 | 1.85             | —                 | —                 | —     | —                  | —                | —      |
| Total                          | 99.83 | 100.09 | 100.10           | 100.00 | 30.15             | 69.85            | 100.01            | 100.00            | 99.76 | 51.06              | 48.64            | 100.00 |

<sup>a</sup>. Ashes of No. 2.<sup>c</sup>. Ashes of No. 3, insoluble in acids.<sup>b</sup>. Ashes of No. 3, soluble in acids.<sup>d</sup>. Iron.<sup>e</sup>. Protoxide of iron.<sup>f</sup>. And protoxide of iron 4.55.<sup>g</sup>. Soluble in acids.<sup>h</sup>. Including organic substances.<sup>i</sup>. Protoxide of iron; traces of manganese.<sup>k</sup>. Carbonic acid.<sup>j</sup>. Insoluble in acids.

1. Spec. grav. = 2.519; grey; dark streak; soap to the touch. From Blaydon-Burn Pit, Tyne-side, where it is made into fire-proof bricks.

2. Spec. grav. = 1.259; conchoidal fracture. Contains a good deal of iron pyrites. Is largely exported.

3. Spec. grav. = 1.269; slaty structure; contains much pyrites, and is not used.

4. Spec. grav. = 1.860; black; hard; brittle; slaty structure. Contains impressions of fossil plants.

5. Spec. grav. = 2.536; blueish-grey; more earthy than No. 4; contains many iron-stone nodules.

6. Spec. grav. = 2.598; possesses a beautiful white colour, and fine granular structure, with mica scales.

7. Spec. grav. = 2.592. A clay-iron-stone, containing very fragile shells of a brown colour.

8. Cannel coal. Spec. grav. = 1.319; black; homogeneous; hard; brittle; conchoidal fracture assumes a fine polish. Specimen analyzed, from Blaydon-Main Pit, Tyne-side.

All the above were dried at 100°.

A comparison of the organic constituents of these coals and bituminous schists, shows a great similarity in their elements. These matters, indeed, only differ from one another in the amount of their ashes, and they have, therefore, been formed in the same way. Deducting the ashes, the elements, in 100 parts, were as follows:

|   | Coal. | Coarse coal. | Cannel coal. | Bituminous schist. |
|---|-------|--------------|--------------|--------------------|
| C | 81.01 | 85.83        | 87.86        | 67.84              |
| H | 6.17  | 5.75         | 6.53         | 6.68               |
| N | 2.44  | 1.76         | 2.09         | 2.37               |
| O | 10.38 | 6.66         | 2.53         | 23.11              |

The bituminous schist shows the only real difference, but this arose from the method of analysis, in which the chemically-combined water, amounting to about 6.6 per cent, was reckoned with the inorganic constituents. Allowing for this, the results approximate to those of the other analyses. The analyses exhibit farther the presence of the vegetable matter in two phases of decomposition, since the cannel and coarse coal contain a greater quantity of carbon and a smaller quantity of oxygen than the two others, and are thus in a less decomposed state. As all are now exposed, in this respect, to the same

conditions, the peculiarity in question must have arisen prior to the deposition of the superincumbent beds.

Rocks of  
the coal  
measure:

A certain connection is also shown to exist between the inorganic constituents of the different members of the formation. This is principally exhibited by the portions insoluble in acids, as these have a definite composition, corresponding to that of the fire-clay. The latter is a distinct silicate of the formula  $\text{Al}_2\text{O}_3, 2 \text{SiO}_2 + 2 \text{H}_2\text{O}$  whereas porcelain-clay has the formula  $2 \text{Al}_2\text{O}_3, 3 \text{SiO}_2 + 3 \text{H}_2\text{O}$ . The muscle-bind is a compound of the first-named silicate with the carbonates of iron and lime; and the relations of the two are rendered evident by the accompanying Table, in which the composition of the fire-clay is calculated as anhydrous.

|                                      | $\text{SiO}_2$ | $\text{Al}_2\text{O}_3$ | $\text{Fe}_2\text{O}_3$ | $\text{CaO}$ | $\text{MgO}$ | $\text{KO}$ |
|--------------------------------------|----------------|-------------------------|-------------------------|--------------|--------------|-------------|
| Fire-clay                            | 62.14          | 31.07                   | 2.24                    | 0.74         | 0.83         | 2.45        |
| Insoluble portion of the muscle-bind | 63.89          | 33.49                   | —                       | 2.01         | 0.61         | —           |

The blue shale, and the inorganic matters of the bituminous schist, form another corresponding series, although differing from the above. The shale is calculated as anhydrous.

|                   | $\text{SiO}_2$ | $\text{Al}_2\text{O}_3$ | $\text{Fe}_2\text{O}_3$ | $\text{FeO}$ | $\text{CaO}$ | $\text{MgO}$ | $\text{KO}$ | $\text{NaO}$ |
|-------------------|----------------|-------------------------|-------------------------|--------------|--------------|--------------|-------------|--------------|
| Blue shale        | 58.99          | 26.19                   | 5.11                    | 5.11         | 0.67         | 1.54         | 2.34        | —            |
| Bituminous schist | 56.51          | 31.89                   | —                       | 7.04         | 1.69         | 0.85         | 1.38        | 0.61         |

The ratio of the silica to that of the oxides  $\text{R}_2\text{O}_3$ , is here the same in both substances; and in regard to the oxides  $\text{RO}$ , the correspondence is equally remarkable. The amount of these latter in the bituminous schist is, however, rather higher than in the shale.

**Brown Coal.**—C. Karsten(1) has analyzed an earthy substance passing into true brown coal, which occurs at the upper part of a brown coal stratum, between Weissenfels and Zeitz, and also near Helbra, between Mansfeld and Eisleben; spec. grav. = 0.9; amount of ashes, 13.5 to 13.6 per cent. At a temperature scarcely above the boiling-point of water, white, heavy fumes are given off; but this action ceases at a temperature of  $120^\circ$ . At a red heat, an oily liquid distils over; and when stirred up in an open vessel, the whole mass becomes fluid, and may be fused into a pitch-like substance. Held in the flame, it burns with the usual bituminous odour. The analysis yielded: carbon, 68.92 per cent; hydrogen, 10.30; oxygen, 20.78; whilst a brown coal, which commonly occurred with it, contained carbon, 64.32 per cent; hydrogen, 5.63; oxygen, 30.05.

Respecting the artificial production of substances resembling coal and brown coal, from wood, see p. 366 of the present Report.

**Air in Brown Coal Mines.**—R. F. Marchand(2) has examined the composition of the air in the brown coal mines at Zscherben, in the

(1) Zeitschr. d. Deutsch. Geolog. Ges. II, 71.

(2) J. Pr. Chem. XLIX, 467.

Air in  
brown  
coal  
mines.

**Halle district.** The air is poor in oxygen and rich in nitrogen in these mines. Samples of 100 vols. each, collected on the same day, yielded respectively :

|               | A.     | B.     | C.     | D.     | E.     | F.     | G.     | H.     |
|---------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Oxygen        | 20·920 | 20·919 | 20·521 | 20·010 | 18·201 | 16·302 | 15·230 | 16·230 |
| Carbonic acid | 0·053  | —      | 0·100  | 0·120  | 0·200  | 0·189  | 0·220  | 0·210  |
| Nitrogen      | 79·027 | —      | 79·379 | 79·870 | 81·599 | 83·409 | 84·450 | 83·560 |

A, air collected at Halle; B, at the entrance of the adit; C, 300 paces in the adit or gallery; D, 600 paces in the gallery; E, 900 paces in the gallery, where the lamp burnt rather dimly; F, farther in, near a deserted cross gallery, where the lamp burnt with difficulty; G, still farther in, where the lamp ceased to burn; H, from another place, where the lamp burnt very badly.

Neither carbonic oxide nor carbonated hydrogen could be detected. According to Marchand, the absorption of oxygen is here effected by the pyrites in the brown coal, but without any accompanying production of carbonic acid.

**Ferruginous Coal-schist.**—C. Schnabel(1) has analyzed some ferruginous coal-schists from the Ruhr and from Bochum, which form beds of 2 feet and more in thickness, between the coal-sandstone and slate-clay. A, from the "Friederika" pits; spec. grav.=2·81. B, from the same locality; spec. grav.=2·197. C, from the "Schürbank and Charlottenburg" pits; spec. grav.=2·94. D, from the same locality; spec. grav.=2·33.

|      | FeO.  | Fe <sub>2</sub> O <sub>3</sub> . | MnO.  | CaO.  | MgO. | Al <sub>2</sub> O <sub>3</sub> . | HC.  | CO <sub>2</sub> . | SO <sub>3</sub> . | C.    | Siliceous residue. | Total. |
|------|-------|----------------------------------|-------|-------|------|----------------------------------|------|-------------------|-------------------|-------|--------------------|--------|
| A    | 48·21 | 1·30                             | 0·13  | 0·59  | 1·20 | 0·77                             | 0·92 | 31·32             | 0·03              | 14·61 | 0·93               | 100·04 |
| B    | 29·32 | 7·46                             | trace | trace | 2·10 | trace                            | 4·14 | 20·22             | trace             | 35·34 | 0·81               | 99·39  |
| C    | 43·41 | 7·77                             | 0·68  | trace | 1·75 | trace                            | 3·01 | 28·80             | trace             | 11·71 | 2·71               | 99·69  |
| D a* | 21·91 | 5·93                             | trace | 0·49  | 0·75 | trace                            | 5·09 | 14·39             | 0·38              | —     | —                  | 99·89  |
| b†   | —     | 1·16                             | —     | 0·48  | 0·34 | 8·67                             | —    | —                 | —                 | 20·07 | 20·23‡             |        |

\* Portion soluble in hydrochloric acid (48·94 per cent.)

† Portion insoluble in hydrochloric acid (50·96 per cent.)

‡ SiO<sub>2</sub>.

**Bituminous Schist.**—N. B. Delahaye(2) has published a detailed monograph on the bituminous schists.

**Fossil Sea-weed.**—A. Bobierre(3) has described and analyzed a deposit of sea-weed, occurring at Kérouan, in the Departement of Finisterre. This deposit has already become converted by superincumbent layers of sand into a solid, fissile, black substance, capable of being used, both as a combustible and as a manure. It consists of, organic matters, 83·3 per cent; chloride of sodium, chloride of

(1) Pogg. Ann. LXXX, 441.

(2) Rev. Scientif. Industr. XXXVIII.

(3) Ann. Ch. Phys. [3] XXX, 376; J. Pr. Chem. LII, 190.

magnesium, chloride of calcium, sulphate of potassa, sulphate of soda, and sulphate of magnesia, 8.0; carbonate of lime and carbonate of magnesia, 1.7; alumina and sesquioxide of iron, 3.0; silica, 4.0. Nitrogen is present to the amount of 18 per cent. 100 parts of the dried substance gave 38 per cent of ammoniacal water (with  $\frac{1}{10}$  tar, the sulphate of ammonia developed from the latter being equal to 4 per cent of the sea-weed employed), 52 per cent of carbonaceous residue, and 10 per cent of ordinary gas. The carbonaceous residue contained: carbon, 66.2 per cent; soluble salts of soda, potassa, and magnesia 15.1; carbonate of lime and carbonate of magnesia, 3.5; alumina and sesquioxide of iron, 5.2; silica, 10.0.

Fossil  
sea-weed.

**Taunus slate.**—K. List(1) has subjected the Taunus slate-rock to a chemical examination(2). This rock has hitherto been universally looked upon as a talcose or chlorite slate, although it contains merely traces of magnesia. The variety examined possessed a red colour passing into violet, together with a silky lustre. In thin splinters it fused before the blow-pipe, if the heat were well kept up, into a black slag. It was obtained from the Nerothale on the road from the Leichtweishöhle to the Matte, but the same variety occurs also in other places. A portion dissolved with a yellow colour in hydrochloric acid, of 30.30 per cent diluted with an equal volume of water. The residue, which amounted to from 84 to 87 per cent, had a slightly greyish colour, and consisted in part of crystalline silky scales, and partly of an amorphous powder. No silica entered into the hydrochloric acid solution; but some was extracted from the residue by boiling with carbonate of soda, although the slate itself did not yield any by this process before the treatment with the acid. The water was determined directly, and the proper quantities allotted by calculation to the soluble and insoluble portions. A, in the following table, represents the composition of the part (17.889 per cent) soluble in hydrochloric acid; and B, that of the insoluble residue (82.111 per cent). C is the composition of the slate as a whole.—A second experiment on the ordinary green variety of the Taunus slate, yielded by treatment with concentrated hydrochloric acid, a residue of 93.757 per cent, which, omitting a feeble amount of chlorine, fluorine, and phosphoric acid, exhibited the composition given under D. E represents the entire composition of one of these common or normal varieties of the Taunus slates, from an analysis by R. Wildenstein.

More lately, List has discovered near Naurod a mineral which agrees very strikingly with the crystalline portion of the different varieties of these slates, and on which he has bestowed the name of

(1) Jahrb. d. Ver. f. Naturkunde im Herzogth. Nassau, 6 Heft, 1850, 126; Jahrb. Miner. 1851, 344; Sandberger, Geognostische Skizze des Taunus in "Die Nassauischen Heilquellen," Wiesbaden, 1851.

(2) Other mineralogico-geological notices on these rocks, by F. Sandberger, are contained in the Jahrb. d. Ver. f. Naturk. im Herz. Nassau, 6 Heft, 1850, 1.

Taunus  
slate.

sericite(1). It occurs in small foliated particles on quartz. The ratios of the bases in this mineral, and in the undecomposed residues of the violet and normal slates, are almost exactly alike. If the amount of the alkalis—reduced from the quantity of the soda found, to the equivalent quantity of potassa—be assumed as unity, and the value of the protoxide of iron be deduced in the same manner from the obtained amount of magnesia, we get the following proportions:

|                      | KO. | FeO.  | Al <sub>2</sub> O <sub>3</sub> . | HIO.  |
|----------------------|-----|-------|----------------------------------|-------|
| In sericite . . .    | 1   | 0.844 | 1.891                            | 0.473 |
| In the residue . . . | 1   | 0.819 | 1.867                            | 0.504 |
| In the normal slate  | 1   | 0.626 | 1.891                            | 0.533 |

List concludes from this, that the normal variety of the Taunus slate is a mixture of sericite and quartz in variable proportions; to which latter circumstance the different degrees of solidity observable in the rock are likewise owing. In the variety of the preceding table, 58.353 per cent of sericite are combined with 41.947 per cent of quartz.

|    | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | FeO.  | MgO.  | CaO.  | KO.   | NaO.  | HIO.  | Total.  |
|----|--------------------|----------------------------------|----------------------------------|-------|-------|-------|-------|-------|-------|---------|
| A. | 27.253             | 7.792                            | 15.822                           | —     | 6.781 | 2.788 | 2.672 | 1.064 | 5.830 | 100.002 |
| B. | 62.174             | 17.086                           | —                                | 7.088 | 6.213 | trace | 6.903 | 1.857 | 4.613 | 99.996  |
| C. | 55.735             | 15.614                           | 8.221                            | 5.820 | 1.393 | 0.501 | 6.162 | 1.706 | 4.848 | 100.000 |
| D. | 76.004             | 9.729                            | —                                | 2.678 | 0.290 | 1.124 | 4.617 | 3.114 | 1.067 | 100.623 |
| E. | 72.87              | 13.71                            | —                                | 3.48  | 0.61  | —     | 5.29  | 1.30  | 3.28  | 100.43  |

**Clay-slate.**—W. Kayser(2) has analyzed a clay-slate occurring as a vein-stone in the Neue Margarethe galena mine in the Hartz. It consisted of:—

| SiO <sub>2</sub> . | Al <sub>2</sub> O <sub>3</sub> . | Fe <sub>2</sub> O <sub>3</sub> . | Mn <sub>2</sub> O <sub>3</sub> . | CaO. | MgO. | KO.  | NaO.  | S.   | Coal. | HIO. | BaO.  | Total. |
|--------------------|----------------------------------|----------------------------------|----------------------------------|------|------|------|-------|------|-------|------|-------|--------|
| 49.87              | 26.41                            | 6.95                             | 1.21                             | 2.10 | 0.87 | 2.96 | 1.615 | 0.39 | 0.65  | 7.05 | trace | 100.08 |

The surface of the slate, by weathering, becomes coated with a saline crust which exhibited the following composition:

| FeO, CO <sub>2</sub> . | MgO, CO <sub>2</sub> . | CaO, CO <sub>2</sub> . | NaO, CO <sub>2</sub> . | HIO. | Total. |
|------------------------|------------------------|------------------------|------------------------|------|--------|
| 0.19                   | 3.32                   | 1.81                   | 92.07                  | 1.85 | 99.24  |

**Salt-clay.**—Schafhäütl(3) has analyzed several bituminous magnesia-marls containing gypsum—the so-called salt-clay—from the rock-salt formation of Berchtesgaden. These marls, as well as specimens from other localities, are distinguished from ordinary clays by the presence of a large amount of carbonate of magnesia, and a certain quantity of sulphide of iron. They are friable, and do not effervesce in acids. The acid only acts effectually after the finely-

(1) See page 507.

(2) Jahrb. Miner. 1850, 682.

(3) Given in abstract in the Münchener Gelehrte. Anzeigen, 1849, No. 183, 125 in Jahrb. Miner. 1850, 706.

pulverized mineral has been freed by washing from the rock-salt and gypsum—a treatment to which all the examined specimens were subjected. The soluble matters consisted of chloride of sodium, chloride of magnesium and gypsum.—I. represents the composition of a light-greyish salt-clay from the so-called Haselgebirg. This variety fills up interstices in the crystals of rock-salt. II. shows the composition of a darker variety; and III. that of a blackish-brown, compact kind. This latter, which was between “soft and very soft,” exhibited an earthy fracture, and gave off, when broken, a strongly bituminous odour. It was very incompletely decomposed by fuming nitric acid. After ignition, sulphuretted hydrogen was disengaged by moistening with hydrochloric acid.

Salt-clay.

|      | SiO <sub>3</sub> . | Al <sub>2</sub> O <sub>3</sub> . | CaO, CO <sub>2</sub> . | MgO, CO <sub>2</sub> . | FeO, CO <sub>2</sub> . | Bitum. | H <sub>2</sub> O. | S.   | Total.  |
|------|--------------------|----------------------------------|------------------------|------------------------|------------------------|--------|-------------------|------|---------|
| I.   | 47.75              | 12.90                            | 4.85                   | 14.450                 | 16.81                  | 2.33   | 0.68              | —    | 99.970  |
| II.  | 53.00              | 17.10                            | 1.85                   | 12.335                 | 14.55                  | 1.18   | —                 | —    | 100.015 |
| III. | 6.45               | 4.80                             | 42.40                  | 40.600                 | 0.90                   | 4.31   | —                 | 0.51 | 99.970  |

**Meteorite Stones.**—According to C. U. Shepard(1), the fall of meteoric stones is principally confined to two zones. The one, belonging to America, lies between 33° and 44° N. lat., and is about 25° in length. Its direction is more or less from north-east to south-west, following the general line of the Atlantic coast. Of all the occurrences of this phenomenon during the last fifty years, 92.8 per cent have taken place within these limits, and mostly in the neighbourhood of the sea.—The zone of the Eastern continent, with the exception that it extends 10° farther to the north, is bounded by the same degrees of latitude, and follows a similar north-east direction; but it has more than twice the length of the American zone. Of the observed falls of aerolites, 90.9 per cent occurred within this area, and were also concentrated in that half of the zone which extends along the Atlantic.—Fourteen localities of meteoric iron are recognized in the Old World, eleven of which fall within the aerolitic zone, between 46° and 52° N. lat. Thirty-two of these localities are known in the New World, of which twenty-three lie within the zone-limits, and mostly, indeed, near the parallel of 36°.

**European Aerolites.**—Shepard(2) has also given a description of the meteoric iron which fell in the County Down in Ireland, on the 10th of August, 1846. This is malleable and homogeneous, but of an amygdaloidal structure. Its spec. grav. is not uniform. That of the vesicular part=5.9. The aerolite is covered with a thick crust, extending in places to the depth of an inch, and consisting partly of sesquioxide of iron and partly of vivianite. In a moist atmosphere, chloride of iron oozes out in minute drops. The speci-

(1) Sill. Am. J. [2] X, 128.

(2) Ibid. XI, 37.



Asiatic  
aerolites.

men does not exhibit Widmanstet's figures; neither does it contain nickel, cobalt, or sulphur.

**Asiatic Aerolites.**—Shepard has likewise drawn up a report on several Asiatic aerolites(1). 1. From Tuttehpore in Hindostan, lat.,  $25^{\circ} 57' N.$  and long.  $80^{\circ} 50' E.$  of Greenwich. This is mentioned by Partsch in his well-known work, page 142. One of the numerous stones which fell at this locality was obtained by Shepard. It of an oval, slightly compressed form, cracked at the edges, and of a brownish-black colour. Its weight is about 2 lbs., and its structure is fine granular and trachytic, very generally resembling the stone of Poltawa (March, 1811), and those of Castine; spec. grav. = 3.352.—2. An aerolite from Charwallas, 30 miles from Hissar in Hindostan, which fell on the 12th of June, 1834. This is also mentioned by Partsch (p. 143), and is in the possession of Professor Jameson of Edinburgh. It weighs about 7 or 8 lbs., and has a very solid appearance, the cracks and interstices being filled up with iron rust, like certain weathered fine-grained granites. On this account, the entire mass appears to consist of nothing else than nickeliferous iron. Most probably, however, it contains olivine and one of the feldspars. By exposure to a damp atmosphere, the specimen absorbs moisture, and shows the presence of sesquichloride of iron; spec. grav. = 3.38. It contains 15.07 per cent of nickeliferous iron, with traces of sulphur. The non-metallic part consists of silica, magnesia, protoxide of iron, alumina, and lime.

**American Aerolites.**—The editors of Silliman's American Journal have given an account of the fall of a meteoric stone, which, according to a letter communicated by J. H. Gibson(2), took place under the usual circumstances, in Cabarras County, North Carolina, on the 31st of October, 1849. The aerolite struck the trunk of a felled pine-tree, and entered it to the depth of ten inches.—C. U. Shepard(3) has published a more detailed description of this stone. It weighed, according to his statement,  $18\frac{1}{2}$  lbs., and had the form of a truncated, obtuse, irregular, four-sided pyramid, with a rounded undulating surface. It possessed also a thin, black, and very continuous crust, and was exceedingly tough. "Colour of the basis, dark bluish-grey, with fine specks of rust and rounded granules and crystals of some transparent mineral scattered through it, giving the substance a porphyritic appearance; spec. grav. 3.60 to 3.66. Analysis showed the following composition: nickeliferous iron, with chromium, 6.320; magnetic pyrites, 3.807; silica, 56.168; protoxide of iron, 18.108; magnesia, 10.406; alumina, 1.797; traces of lime, soda, and potassa, and loss 3.394. Total, 100.000.

(1) Sill. Am. J. [2] XI, 36.

(2) Sill. Am. J. [2] IX, 143; "Instit. 1850, 183; Phil. Mag. [3] XXXVI, 240.

(3) Sill. Am. J. [2] X, 127.

C. U. Shepard(1) has also described a meteoric stone, which fell, during a violent thunderstorm, in the summer of 1846, at Richland in South Carolina. The stone in question was almost perfectly round,  $2\frac{1}{10}$  inches in diameter, and  $6\frac{1}{2}$  oz. in weight; it had a dark, reddish-brown, vitreous coating, and resembled in the interior a brick, both in fracture and colour. Its spec. grav. amounted to 2.32, and its composition was as follows: silica, 80.420; alumina, 15.680; protoxide of iron, 2.513; magnesia, 0.700; lime, 0.500: total, 99.813. The alkalis were not sought for.

Shepard(2) has likewise given an account of a large stone of this kind from Linn County, Iowa(3), and of another from Waterloo in Seneca County, New York. He obtained from the first a specimen weighing 20 lbs. This exhibited a very regular prismatic form, not unlike a basaltic column. The second fell through the top of a house in the summer of 1826 or 1827. In colour and texture it resembled a rhubarb root, and was so slightly coherent as to be readily broken by the pressure of the fingers; spec. grav. = 2.30. It had a reddish-brown crust, and contained a small quantity of blackish particles attractable by the magnet. Analysis showed: silica, 78.80 per cent; sesquioxide of iron, 8.72; alumina, 6.28; water, 4.75; lime, magnesia, and loss, 1.45.

Shepard(4) has announced furthermore, that the meteoric iron of Ruffs Mountain, Newberry, South Carolina, has a similar structure to that from Texas and Carthago (Tennessee); but that it is distinguished from the latter by possessing small string-like fissures or veins, filled by an apparently new species of iron pyrites. The spec. grav. of the internal mass was found = 7.01 to 7.10; and that of the outward portion, which contains intermixed magnetic iron; from 5.97 to 6.80. The analysis yielded: iron, 96.000; nickel, 3.121, with traces of chromium, sulphur, cobalt, magnesium, and chlorine; total, 99.121.—Finally, Shepard(5) has given the spec. grav. of the meteoric iron from Pittsburg, and of that from the Salt River: the first = 7.380; the second, 6.835.

**African Aerolites.**—The English traveller, Richardson(6), in a letter from Jerbah, of the 25th of January, 1850, has reported the occurrence of a shower of aerolites, which took place two months previously, accompanied by a vivid stream of light, on the African coast between Tunis and Tripoli. Several stones fell in Tripoli itself.

(1) Sill. Am. J. [2] X, 127.

(2) Ibid. XI, 38.

(3) Annual Report for 1847 and 1848, II, 517.

(4) Sill. Am. J. [2] X, 128.

(5) Sill. Am. J. [2] XI, 40. The *chladnite*, mentioned in the Report for 1847 and 1848, II, 520, consists, according to Shepard, of 70.41 per cent of silica, 28.25 of magnesia and 1.39 of soda. It does not contain a trace of alumina (Sill. Am. J. [2] VI, 414; Dana's Syst. of Mineral. 3rd edit. 683).

(6) Edinb. New Philos. Journ. I., 181.

Meteoric  
dust.

**Meteoric Dust.**—Ehrenberg(1) has contributed a new and very instructive essay on the nature of meteoric dust, occasioned by an examination of the so-called red snow, found on the highest of the St. Gothard Alps, on the 17th of February, 1850, during a period of calm which followed an occurrence of the Föhn winds.—Some of this snow from Hospenthal, in the Urserenthal, 4566 feet high, had already been examined by Perty(2), who announced that it consists of the red snow-alga, *Protococcus nivalis*, mixed with atmospheric dust composed of particles of some colourless rock-substance. It was the opinion of this latter observer that these organisms—which occurred over a great part of the Canton Uri, the Grisons, and the Bernese Oberlands—were developed with extreme rapidity under the influence of warm days accompanied by the warm Föhn winds. In its chemical examination, conducted by Brunner, Jun.(3), it exhibited the behaviour of an animal substance, giving off, when heated in a closed tube, an ammoniacal odour, with the deposition of alkaline matters. The incombustible residue behaved like ordinary mineral dust. Perty believes, however, that various vegetable organisms comport themselves chemically like animal bodies—*Oscillatoria rubens*, for example, which in 1825 imparted a blood-red colour to a large extent of the Murten-see—and that chemistry alone is not able to distinguish plants from animals. A. Escher von der Linth(4), on the other hand, has considered that the greater part of this red dust consists of volcanic matters derived from Vesuvius.—Ehrenberg, however, after a very careful microscopic examination, has arrived at a totally different conclusion. The specimen transmitted to him from Switzerland, was of a clear brown or greyish-yellow colour, like the Tyrolese snow-dust of the 31st of March, 1847(5). He found in it an extraordinary quantity of different substances (amounting altogether to 60) 47 of which consisted of organic siliceous bodies, comprising 30 perfectly determinable shells of polygastric infusoria, and seventeen phytolitharia, these latter including spicula of fresh-water sponges. The other organic matters comprised pollen corpuscles, and minute seeds of different kinds; also particles of soft vegetable tissues, and hairs and fibres of plants, in part resembling minute threads of flax or cotton. Ehrenberg was undecided respecting these, as to whether they were derived from the filter employed by him, or actually constituted a portion of the matters examined. In the latter case, it is probable that particles of our clothes, &c., in an extreme state of subdivision, may float about in

(1) Berl. Acad. Ber. 1850, 169; Froriep's Tagesber. üb. d. Fortschritt d. Natur-u. Heilk. 1850, No. 176, 201.

(2) Ibid.; Supplement to the Allgem. Augsburger Zeitung of March 27th, 1850.

(3) Mitth. der Berner Naturf. Gesellsch. December, 1850.

(4) Berl. Acad. Ber. 1850, 175.

(5) Annual Report for 1847 and 1848, II, 522.

the atmosphere as meteoric dust. Besides the above matters, various inorganic substances were detected. These consisted of crystalline, brown, silvery, and gold-like micaceous particles; greenish and deep yellow splinters resembling olivine and chrysolite; hyacinth-red, vitreous fragments (garnet?), together with colourless and porphyritic splinters. Also, brick-red earthy particles; feldspathic particles; green prismatic crystals; six-sided tabular crystals; rounded, dark green, faceted crystals; calcareous morpholite; amorphous quartz-sand; and amorphous particles of carbonate of lime. On account of the similarity of the organisms to those in the trade-wind meteoric dust of St. Jago, one of the Cape de Verd Islands, Ehrenberg considers that the present dust was also due to the agency of the Atlantic trade-winds. In his opinion, likewise, the inorganic substances, which in other respects only admitted of an approximate determination, are not in the main composed of volcanic matters. He founds this opinion upon their refractive properties when examined in coloured polarized light, according to a method already successfully employed by him in the examination of kindred bodies. He detected, however, some traces of volcanic products, which might certainly have originated from Vesuvius, as an eruption of ashes from that volcano—of sufficient intensity to effect the transmission of part of the ejected matters into the “dust-stratum” of the upper trade currents—took place on the 9th of February of the same year; and the whirlwinds thus caused, occasioned a diversion of the Atlantic meteoric dust at that season.

The dust-mist borne along in this manner by the Föhn, wind at a height of more than 10,000 feet, met in the vicinity of St. Gothard, a counter current coming from the north. This originated a calm, during which the dust-mist fell, and covered all the highest peaks of the mountain. Deposits of this kind, exhibit themselves again by the melting of the after-fallen snows, as a brown layer or coating on the surface of the district, or appear in escarped snow-breaks in the form of bands, thus elucidating the occurrence of these organisms in glacier ice(1).

(1) See Berl. Acad. Ber. 1849, 298.



## SYMBOLS AND EQUIVALENTS USED IN THE ANNUAL REPORT.

|            |            |            |            |
|------------|------------|------------|------------|
| Aluminum   | Al = 13.7  | Nickel     | Ni = 29.6  |
| Antimony   | As = 129   | Niobium    | Nb = .     |
| Arsenic    | As = 75    | Nitrogen   | N = 14     |
| Barium     | Ba = 68.5  | Norium     | No = .     |
| Beryllium  | Be = 4.7   | Osmium     | Os = 99.6  |
| Bismuth    | Bi = 213   | Oxygen     | O = 8      |
| Boron      | B = 10.9   | Palladium  | Pd = 53.3  |
| Bromine    | Br = 80    | Pelopium   | Pe = .     |
| Cadmium    | Cd = 56    | Phosphorus | P = 32     |
| Calcium    | Ca = 20    | Platinum   | Pt = 98.7  |
| Carbon     | C = 6      | Potassium  | K = 39.2   |
| Cerium     | Ce = 47    | Rhodium    | R = 52.2   |
| Chlorine   | Cl = 35.5  | Ruthenium  | Ru = 52.2  |
| Chromium   | Cr = 26.7  | Selenium   | Se = 39.5  |
| Cobalt     | Co = 29.5  | Silicium   | Si = 21.3  |
| Copper     | Cu = 31.7  | Silver     | Ag = 108.1 |
| Didymium   | D = 50     | Sodium     | Na = 23    |
| Erbium     | E = .      | Strontium  | Sr = 43.8  |
| Fluorine   | Fl = 19    | Sulphur    | S = 16     |
| Gold       | Au = 197   | Tantalum   | Ta = 184   |
| Hydrogen   | H = 1      | Tellurium  | Te = 64.2  |
| Iodine     | I = 127.1  | Terbium    | Tb = .     |
| Iridium    | Ir = 99    | Thorium    | Th = 59.6  |
| Iron       | Fe = 28    | Tin        | Sn = 58    |
| Lanthanium | La = 47    | Titanium   | Ti = 25    |
| Lead       | Pb = 103.7 | Tungsten   | W = 92     |
| Lithium    | Li = 6.5   | Uranium    | U = 60     |
| Magnesium  | Mg = 12    | Vanadium   | V = 68.6   |
| Manganese  | Mn = 27.6  | Yttrium    | Y = .      |
| Mercury    | Hg = 100   | Zinc       | Zn = 32.6  |
| Molybdenum | Mo = 46    | Zirconium  | Zr = 22.4  |

N.B.—THE ATOMIC WEIGHTS AND EQUIVALENTS ARE ASSUMED TO BE EQUAL.

## Abbreviations in the References.

The numbers in [brackets] indicate that the volume quoted belongs to a series (*séries, Folge*) represented by such numbers.

|                         |        |                                                                                                                                                                                                           |
|-------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ann. Ch. Pharm.         | sign.: | Annalen der Chemie und Pharmacie, herausgegeben von Wöhler und Liebig.—Heidelberg.                                                                                                                        |
| Ann. Ch. Phys.          | „      | Annales de chimie et de physique, par Gay-Lussac, Arago, Chevreul, Dumas, Pelouze, Boussingault et Regnault.—Paris.                                                                                       |
| Ann. Min.               | „      | Annales des mines, rédigées par les ingénieurs des mines.—Paris.                                                                                                                                          |
| Arch. Pharm.            | „      | Archiv der Pharmacie, herausgegeben von Wackenroder und Bley.—Hannover.                                                                                                                                   |
| Arch. Ph. Nat.          | „      | Archives des sciences physiques et naturelles, par de la Rive, Marignac, Pictet, de Candolle, Gautier, Plantamour et Favre.—Genève.                                                                       |
| Berl. Acad. Ber.        | „      | Monatsberichte der Academie der Wissenschaften zu Berlin.                                                                                                                                                 |
| Bull. Géol.             | „      | Bulletin de la société géologique de France.—Paris.                                                                                                                                                       |
| Chem. Gaz.              | „      | Chemical Gazette, conducted by Francis.—London.                                                                                                                                                           |
| Chem. Soc. Mem.         | „      | Memoirs and Proceedings of the Chemical Society of London.—London.                                                                                                                                        |
| Chem Soc. Qu. J.        | „      | The Quarterly Journal of the Chemical Society of London.—London.                                                                                                                                          |
| Compt. Rend.            | „      | Comptes rendus hebdomadaires des séances de l'académie des sciences.—Paris.                                                                                                                               |
| Ding. Pol. J.           | „      | Polytechnisches Journal, herausgegeben von G. J. Dingler und E. M. Dingler.—Stuttgart.                                                                                                                    |
| Jahrb. Mincr.           | „      | Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefactenkunde, herausgegeben von Leonhard und Bronn.—Stuttgart.                                                                                |
| Jahrb. Pr. Pharm.       | „      | Jahrbuch für practische Pharmacie, redigirt von Hoffmann, Winckler und Zeller.—Landau.                                                                                                                    |
| Instit.                 | „      | L'Institut; section des sciences mathématiques, physiques et naturelles, dirigé par Arnould.—Paris.                                                                                                       |
| J. Chim. Méd.           | „      | Journal de chimie médicale par Béral, Chevallier, Dumas, Fée, Guibourt, Lassaigue, Orfila, Payen, Pélilot, Pelletan, Pelouze, Richard et Robinet.—Paris.                                                  |
| J. Pharm.               | „      | Journal de pharmacie et de chimie, par Boullay, J. P. Boudet, Bussey, Soubeiran, Henry, F. Boudet, Cap, Boutron-Charlard, Frémy, et Guibourt; contenant une revue des travaux de chimie par Wurtz.—Paris. |
| J. Pr. Chem.            | „      | Journal für practische Chemie, herausgegeben von Erdmann und Marchand.—Leipzig.                                                                                                                           |
| Laur. und Gerh. C. R.   | „      | Comptes Rendus des travaux de chimie, par Laurent et Gerhardt.—Paris.                                                                                                                                     |
| Petersb. Acad. Bull.    | „      | Bulletin de la classe physico-mathématique de l'acad. de St. Pétersbourg.                                                                                                                                 |
| Pharm. Centr.           | „      | Pharmaceutisches Centralblatt, redigirt von Knop.—Leipzig.                                                                                                                                                |
| Pharm. J. Trans.        | „      | Pharmaceutical Journal and Transactions, edited by Bell.—London.                                                                                                                                          |
| Phil. Mag.              | „      | The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, conducted by Brewster, Taylor, Phillips and Kane.—London.                                                                |
| Pogg. Ann.              | „      | Annalen der Physik und Chemie, herausgegeben von Poggendorff.—Leipzig.                                                                                                                                    |
| Repert. Pharm.          | „      | Repertorium für die Pharmacie, herausgeg. von Buchner.—Nürnberg.                                                                                                                                          |
| Rev. Scientif. Industr. | „      | Revue Scientifique industrielle, sous la direction de Quesneville.—Paris.                                                                                                                                 |
| Sill. Am. J.            | „      | The American Journal of Science and Arts, conducted by Silliman, Silliman, Jun., and Dana.—Newhaven.                                                                                                      |
| Wien. Acad. Ber.        | „      | Sitzungsberichte der Wissenschaften zu Wien.                                                                                                                                                              |

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# ABBREVIATIONS IN THE INDEX.

|                       |                        |
|-----------------------|------------------------|
| Act. . . . .          | Action.                |
| Anal. . . . .         | Analysis.              |
| Appl. . . . .         | Application.           |
| Boil. p. . . . .      | Boiling-point.         |
| Comb. . . . .         | Combination.           |
| Comp. . . . .         | Compare.               |
| Compos. . . . .       | Composition.           |
| Cond. r. . . . .      | Conduction-resistance. |
| Const. . . . .        | Constitution.          |
| Cryst. f. . . . .     | Crystalline form.      |
| Decomp. . . . .       | Decomposition.         |
| Deport. . . . .       | Department.            |
| Determ. . . . .       | Determination.         |
| Detect. . . . .       | Detection.             |
| Electr. . . . .       | Electricity.           |
| equiv. . . . .        | Equivalent.            |
| Exp. . . . .          | Expansion.             |
| Exam. . . . .         | Examination.           |
| Form. . . . .         | Formation.             |
| Fus. h. . . . .       | Fusion-heat.           |
| Fus. p. . . . .       | Fusing-point.          |
| Invest. . . . .       | Investigation.         |
| Lat. fus. h. . . . .  | Latent fusion-heat.    |
| Lat. h. . . . .       | Latent heat.           |
| Lat. vap. h. . . . .  | Latent vapour-heat.    |
| Occur. . . . .        | Occurrence.            |
| Opt. deport. . . . .  | Optical deportment.    |
| Org. subst. . . . .   | Organic substance.     |
| Precip. . . . .       | Precipitation.         |
| Prod. . . . .         | Product.               |
| Prep. . . . .         | Preparation.           |
| Prop. . . . .         | Properties.            |
| Recogn. . . . .       | Recognition.           |
| Separ. . . . .        | Separation.            |
| Solut. . . . .        | Solution.              |
| Sol. . . . .          | Soluble.               |
| Spec. grav. . . . .   | Specific gravity.      |
| Spec. h. . . . .      | Specific heat.         |
| Subst. . . . .        | Substance.             |
| Temp. . . . .         | Temperature.           |
| Tens. of vap. . . . . | Tension of vapour.     |

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